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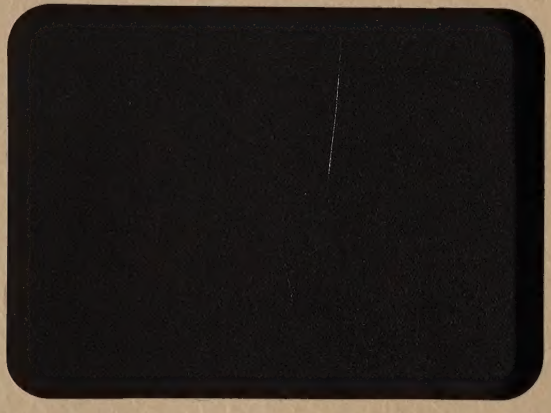

LING ELECTRONICS, INC.

MP MASTER
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SUBSIDIARY OF MECHANICAL TECHNOLOGY INC

Model
TAP-1000
Test Article Protector

Instruction Manual
M706723B Serial No. 196
& UP

0188

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SECTION 1
INTRODUCTION

1.1 General Description

The TAP-1000 Test Article Protector monitors an alternating acceleration signal (either Peak or RMS) and digitally displays the current level of acceleration and its corresponding displacement. The TAP-1000 compares the current level of acceleration and displacement against the operating limits set and displayed on the front panel pushwheel switches. Acceleration or displacement higher than the upper limit will initiate a soft system shutdown via an optically isolated compressor circuit. After the minimum test level of acceleration has been attained, an under-acceleration condition (loss of signal) will also initiate soft shut down. Shut down will also be automatically initiated by temporary or long term power line fault. Immediate shut down can be further accomplished by using the emergency stop button provided on the front panel or through an external interlock fault loop (both normally closed and normally open) which allows protection by other than the acceleration signal.

The TAP-1000 input amplifier can be used with most piezo-electric accelerometers as well as with resistive or voltage generating transducers or normalized signal outputs. The input amplifier generates a normalized voltage output (selectable 1 or 10 mV/g) for internal use as well as for use with other system devices.

When **Charge Input** is selected the TAP-1000 functions as a "true" charge amplifier for use with accelerometers having an output of 1 to 110 pC/g. It can also be used with voltage inputs of 1 to 110 mV/g when **Voltage Input** is selected.

An adjustable current source is provided for use with resistive type transducers.

Inputs are available to allow remote operation of the TAP-1000 by either manual switch or TTL compatible digital signals. The acceleration signal can be monitored either directly from an accelerometer utilizing the built-in charge amplifier (compatible with most common piezo-electric accelerometers) or a normalized voltage signal proportional to acceleration can be used.

Outputs include an optically isolated soft shutdown compressor circuit which reduces the amplitude of any external signal using the circuit by 10 dB within 3 ms of fault detection. After further reduction of the signal to below -30 dB, a relay is deactivated placing a short on the compressor

output terminals and a 100k Ohm open on the input terminals. Two undedicated relays are provided for external interfacing of the TAP-1000 shut-down status. Any fault detected, immediately switches the Shut-Down relay contacts, followed in approximately 500 ms by switching of the Delay Shut-Down relay contacts. Relay contacts are also provided that switch when the monitored level of acceleration has exceeded the minimum test level set by the front panel pushwheel switches indicating that the current test level is within all of the predetermined test limits.

1.2 Piezoelectric Accelerometer/Charge Amplifier Basics

One of the most common and practical ways to monitor vibration and vibration testing is by the use of modern piezoelectric accelerometers. They are readily available in many configurations, sizes and sensitivities and have excellent frequency response characteristics when monitored by the correct type of electronics. Piezoelectric accelerometers are basically charge generating devices. That is, they are effectively a capacitor which produces a charge upon its plates that is proportional to the force applied to its crystal. By suspending a mass away from the accelerometers' base on a piezoelectric crystal (Fig 1-1) the force required to accelerate the suspended mass to the same levels as the accelerometers' base must be supplied through the accelerometers' crystal.

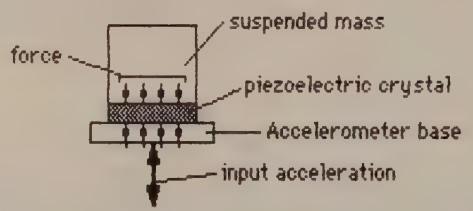


Figure 1-1 Piezoelectric accelerometer

In this manor, the accelerometer generates a charge that is proportional to the the force exerted and therefore proportional to the the accelerometers' base acceleration. The equivalent circuit for an accelerometer is fairly complex (Fig 1-2), but for practical use, the internal shunt resistance and inductance can be neglected to yield a reasonable equivalent circuit as shown in Figure 1-3.

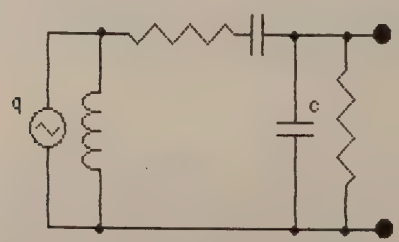


Figure 1-2 Accelerometer equivalent

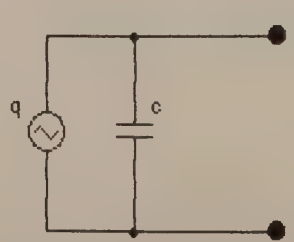


Figure 1-3 Simplified equivalent

Since the output of the transducer is charge, the voltage signal that results is dependent upon the total system capacitance. The cables that must be used to connect the accelerometers to the monitoring electronics and the monitoring electronics themselves can have a significant shunt capacitance associated with them (Fig. 1-4).

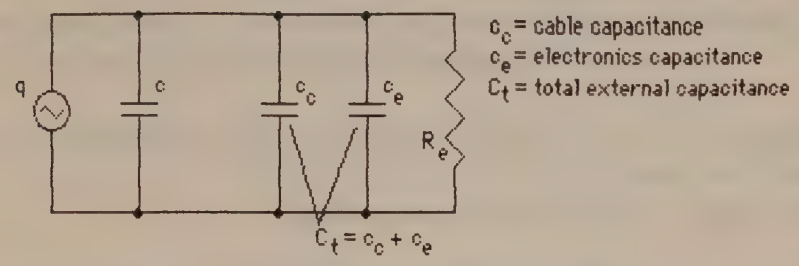


Figure 1-4 Cable and electronics capacitance

Therefore, the voltage that is available across the input resistance to the monitoring electronics is dependent upon the cable capacitance by the relation:

$$e = \frac{q}{C_i + C_C}$$

Where: e= voltage output
q= charge generated
C_i= internal capacitance
C_C= cable and monitoring electronics capacitance

In order to maintain a calibration independent of the length of accelerometer cable and the input capacitance of the monitoring electronics, an amplifier/converter can be used that measures the charge generated by the transducer directly. This charge signal is constant and independent of the internal or additional shunt capacitance found in the transducer and system. Calibration based on charge output can be transferred to the field independent of cables and cable length. Most manufactures of piezoelectric accelerometers provide the charge sensitivity of each unit as part of their final test and calibration, and this sensitivity can be used directly with a charge measuring amplifier to provide calibrated output voltage signals.

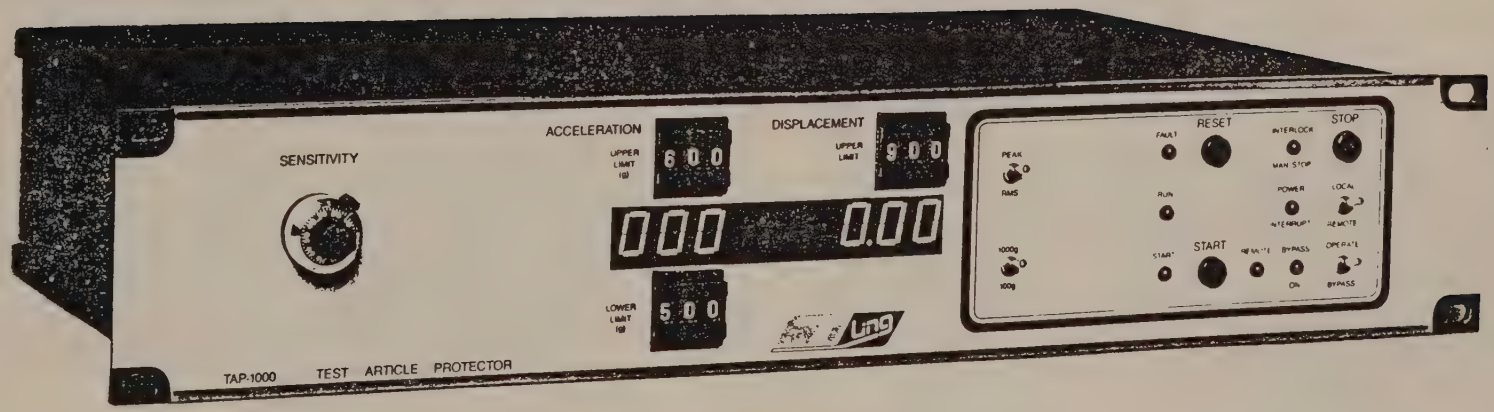
1.3 Technical Specifications:

PARAMETERS	SPECIFICATIONS
Acceleration level	Sine: 0 to 99.9 g or 0 to 999 g Peak Random: 0 to 49.9 g or 0 to 499 g rms
Displacement level	Sine: 0 to 9.99 inch (99.9 mm) Peak-Peak Random: 0 to 4.99 inch (49.9 mm) rms
Input sensitivity:	1 to 110 pC/g or 1 to 110 mV/g
Monitor sample rate:	≈96 samples/sec.
Display update rate:	≈2 updates/sec.
Monitor Fault detection time:	Sine: ≈10 ms above 200 Hz ≈ 2(1/f) below 100 Hz Random: ≈300 ms
Interlock/emergency Fault detection time:	100 micro-sec max.
Power line fault detection time:	≈16 ms
Shut down time:	to -10 dB: 3 ms max. to -60 dB: 20 ms max. to relay clamp ≈ 100 ms.
Power requirements:	115/230 VAC, 50/60 Hz, 40 VA max.
Dimensions:	3.5 in (89 mm) High x 19 in (457 mm) wide x 12 in (305 mm) deep

SECTION 2
FRONT AND REAR PANEL FEATURES

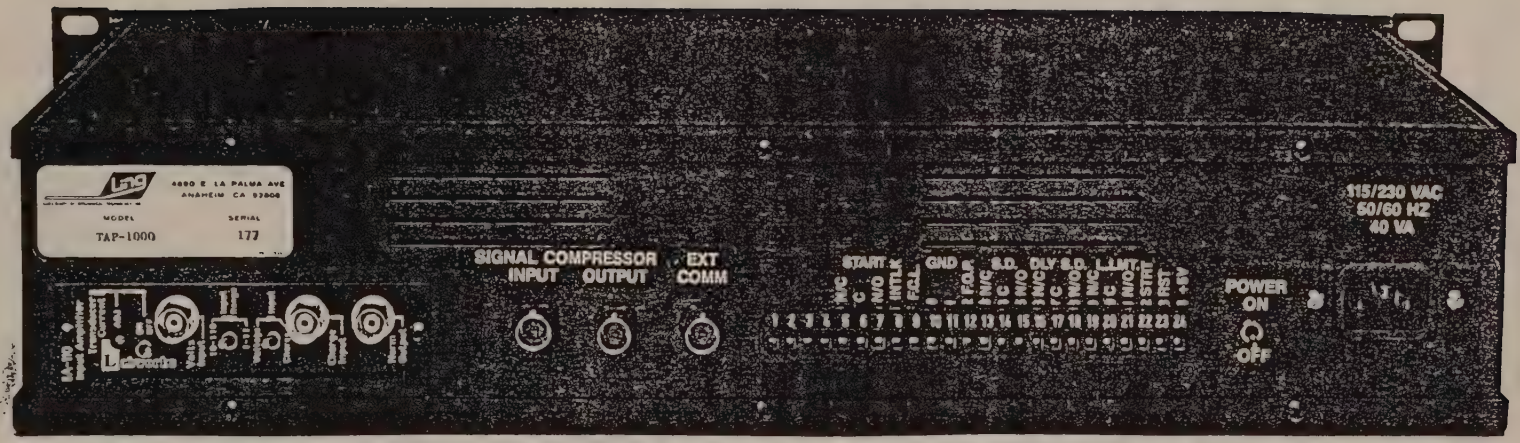
2.1 Front Panel Features (Ref. Fig. 2-1)

Sensitivity Adjustment	A 10 turn manual adjustment used to set the sensitivity of the input acceleration signal. It is used to set the correct accelerometer signal level for accurate calibration.
Detector Mode Switch	A two position toggle switch determines if the input signal is to be displayed and monitored in either its **peak** or **rms** value. (S11)
Monitor Range Switch	A two position toggle switch determines the range of the acceleration to be monitored. This switch scales the digital display as well as the Limit Set Pushwheel Switches. LED decimal point indicators signal the significant digits: **999 g** or **99.9 g** maximum. (S12)
Limit Set Pushwheel Switches	Three sets of three digital display switches are provided to establish each of the selectable limits (acceleration upper test limit S1, S2 and S3, acceleration lower test limit S4, S5 and S6 and displacement upper test limit S7, S8 and S9). These switches have the same numerical significance (determined by the Monitor Range Switch and the Detector Mode Switch) as, and are positioned above and below, the corresponding acceleration or displacement Digital Panel Meters.
Status Indicator Lamps	Three LED lamps signal the status of the TAP-1000 operation. The yellow **Start** indicator signals that the unit is operational and that the compressor circuit is closed. The green **Run** indicator lights when the lower limit set level for acceleration has been exceeded. If the monitored acceleration falls below the set lower limit after this lamp is on, a soft shutdown will be initiated. A red **Fault** indicator signals that a shut down has been executed.



Front Panel Detail
FIGURE 2-1

Reset Button	The **Reset** button is used to reset the TAP-1000 on power up or after a fault has been detected. (S13)
Start Button	Places the TAP-1000 in the operate mode and closes the compressor circuit. (S14)
Fault Indicators	If a fault is detected in the monitored acceleration or displacement the **Fault** indicator will light and the monitored fault level will be flashed on the digital display. If the fault is due to either a manual stop or an external interlock the condition will be indicated by the red **Interlock/Man Stop** lamp. Should the line power to the TAP-1000 be interrupted for more than approximately 16 ms a soft shut down will be initiated. If the power is restored within approximately 1-2 seconds the red **Power Interrupt** indicator will light to indicate the reason for shut down and the levels prior to shut-down will be displayed.
Bypass Indicator	This red indicator flashes at all times that the TAP-1000 is in the compressor bypass mode.
Stop Button	This is a push button for use in emergency shutdown situations. Pressing this button initiates immediate soft shut down. (S15)
Operate/Bypass Switch	This two position toggle switch is used to place the unit in the By-pass mode for set-up, calibration and unprotected operation. In the By-pass mode the start indicator will light and the digital display is functional but all acceleration and displacement level protective circuitry is disabled. (S17)
Local/Remote Switch	This two position toggle switch is used to allow operation of the TAP-1000 via remote host computer over the serial communication interface. (S16)



Rear Panel Detail

FIGURE

2.2 Rear Panel Features (Ref. Fig. 2-2)

Compressor Signal Input and Output	30 V pk max. This circuit has a constant 1k Ohm series resistance in the "on" condition which changes upon shut-down to 100k Ohms across the input terminals and approximately 1k Ohm resistance across the output terminals with no signal voltage present. [Isolated BNC connectors J6 and J7]
Shut Down and Delay Shut Down Relays	NC, NO and Common terminals are available and rated for .25 Amp and 28 V. [Pluggable Terminal Strip J9-13 through J9-18]
Lower Limit Relay	NC, NO and Common terminals are available and rated for .25 Amp and 28 V. [Pluggable Terminal Strip J9-5 through J9-7]
Emergency Stop and Ext. Interlock Inputs	Switch based interlock loops and emergency stop inputs. Loop current is approximately 5 mA at 5 Vdc. Fault closed (normally open J9-9) as well as Fault open (normally closed J9-12) inputs are provided. [Pluggable Terminal Strip J9-8, J9-9 and J9-12]
External Serial Comm.	Bi-Directional Serial communication is provided for by the isolated BNC connector J8.
Remote Start, Reset and Bypass	Remote **Start** can be accomplished by applying +5 Vdc [Pluggable Terminal Strip J9-24] momentarily to the START terminal [Pluggable Terminal Strip J9-22]. Likewise, remote **Reset** is accomplished by connecting +5 Vdc to RESET [Pluggable Terminal Strip J9-23]. Remote **Bypass** operation is accomplished by holding the BYPASS terminal [Pluggable Terminal Strip J9-3] to +5 Vdc when in the **Reset** mode (or when followed by a **Reset**).
+12 Vdc	+12 Vdc low current interlock control voltage is available at pluggable terminal Strip J9-3.
Line Power Switch	The TAP-1000 line power toggle switch.

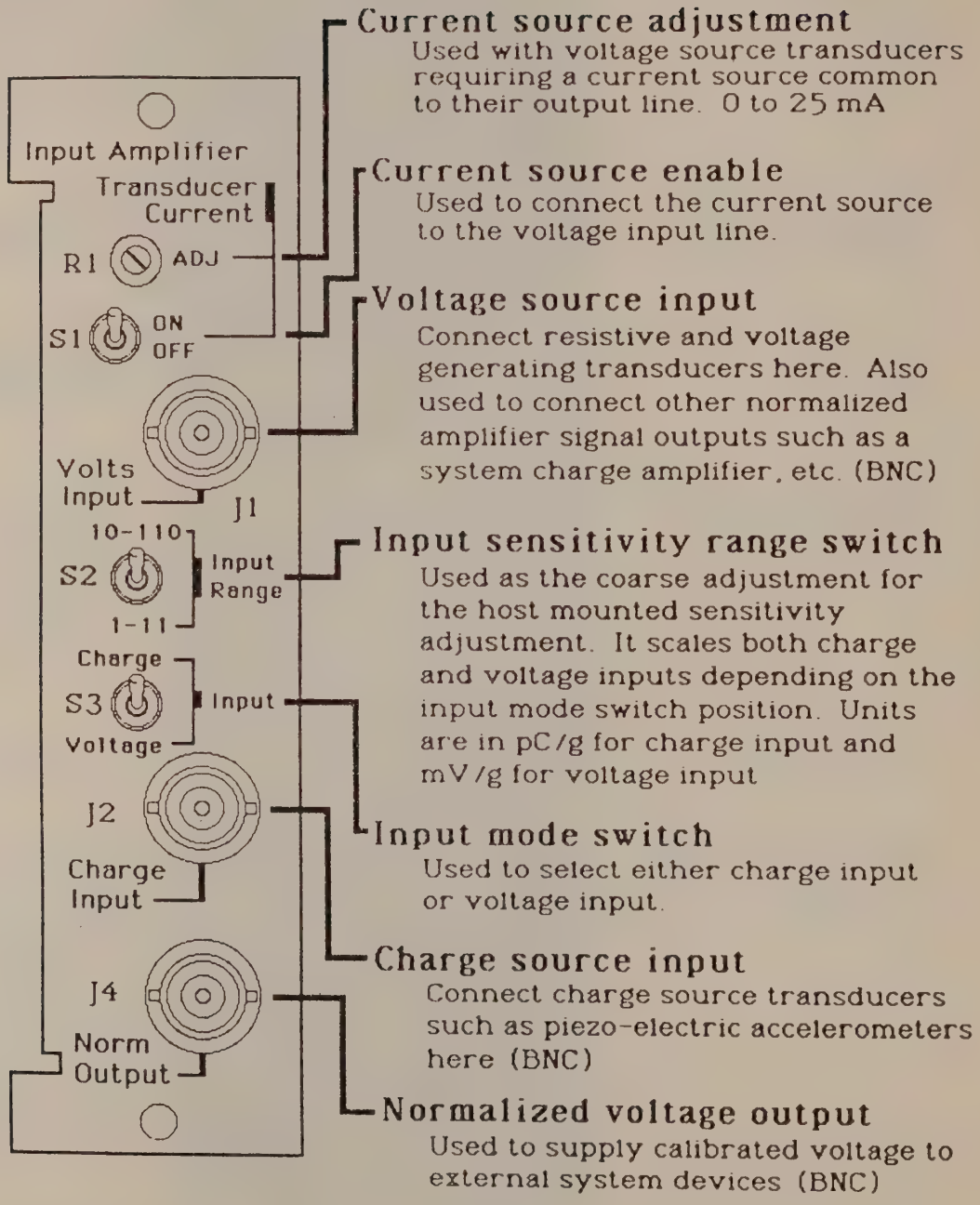

Input Amplifier
Transducer Current
R1
ADJ
S1
ON
OFF
Volts Input
J1
10-110
S2
Input Range
1-11
Charge
S3
Input
Voltage
J2
Charge Input
J4
Norm Output
Current source adjustment
Used with voltage source transducers requiring a current source common to their output line. 0 to 25 mA
Current source enable
Used to connect the current source to the voltage input line.
Voltage source input
Connect resistive and voltage generating transducers here. Also used to connect other normalized amplifier signal outputs such as a system charge amplifier, etc. (BNC)
Input sensitivity range switch
Used as the coarse adjustment for the host mounted sensitivity adjustment. It scales both charge and voltage inputs depending on the input mode switch position. Units are in pC/g for charge input and mV/g for voltage input
Input mode switch
Used to select either charge input or voltage input.
Charge source input
Connect charge source transducers such as piezo-electric accelerometers here (BNC)
Normalized voltage output
Used to supply calibrated voltage to external system devices (BNC)

FIGURE 2-3
Input Amplifier Control Functions

2.3 Input Amplifier Features (Ref. Fig. 2-3)

Charge Source Input	(pC/g) [sig. ground ref. BNC connector J2]
Voltage Input	(mV/g) [sig. ground ref. BNC connector J1]
Range Switch	This two position toggle switch [S2] determines the sensitivity adjustment range of 1 to 11, or 10 to 110 pC/g or mV/g.
Input Mode Switch	A two position toggle switch [S3] determines whether an accelerometer signal or a voltage signal is to be monitored: pC/g or mV/g.
Current Source Enable	A two position toggle switch [S1] connects a current source to the voltage input line to enable use of voltage source transducers.
Current Source Adjust	A trim pot [R1] is used to vary the current source from 0 to 25 mA when it is enabled via S1.
Normalized Voltage Out	A BNC connector [J4] is used to supply calibrated voltage to external system devices.

SECTION 3
OPERATION

3.1 Purpose

The TAP-1000 test article protector is designed to provide a means of monitoring acceleration and displacement, either peak or rms, of a test specimen and initiating a rapid soft shutdown of the test in progress if certain parameters are met. The primary purpose of the TAP-1000 is to prevent over acceleration, under acceleration (loss of signal), or over displacement of the test article and, as such, these limits are accurately adjustable over a wide range. These set limits as well as other factors such as power interrupt, external interlocks, and emergency stop are constantly monitored when the protective circuitry is enabled. This enabled or **Operating** mode is indicated whenever the yellow START indicator is on and the red BYPASS indicator is not flashing. In addition to the operating mode the unit may also be in the **Fault, Bypass** or **Reset** modes. These modes will be described in the following discussion and examples.

3.2 Reset Mode

The **Reset Mode** is the condition which exists upon "power up" or following the actuation of the front panel or remote **Reset** switch. In this mode the output of the TAP-1000 is compressed and the shut down and delay shut down relay contacts are in their switched states. Front Panel settings (Range, Peak/RMS, Local/Remote, Level Settings, etc.) must be made in this mode prior to pressing the start button. Changes in any front panel settings other than Level Settings or Gain after the **Start** Button is pressed will cause a fault. It should be noted that setting the acceleration limit pushwheels in excess of 4.99 inches (49.9 mm) RMS or 499 g's RMS (49.9 g's with 100 g range selected) will cause **HHH** to be displayed. The display will return to normal when the offending limit is reduced. The digital displays indicate the acceleration and displacement of the test article as well as the decimal place for the limit settings (Range) and should be checked before entry into either the bypass or operate mode.

Warning: Before exitting the Reset or Fault Modes be sure that any Servos have been reset and/or the system gain has been turned down. Failure to do so may result in serious damage to both the test specimen and the vibration transducer since decompression of the output takes place instantaneously when either the START button is pressed or the BYPASS mode is selected. If a Fault is Reset with Bypass selected the Bypass mode is entered immediately.

3.3 Bypass Mode

The **Bypass Mode** indicated by both the yellow Start light and the blinking red Bypass light is entered from the Reset mode by moving the Operate/Bypass Switch to Bypass. The Bypass mode is also entered whenever the Reset button is actuated with the selector in the Bypass position (see previous ***Warning***). While in this mode the output is not compressed and the acceleration and displacement protective circuitry is disabled. The front panel settings can be changed in the Bypass mode and will be reflected in the acceleration and displacement displays.

The Bypass mode will normally be exitted directly to the Reset mode by moving the Operate/Bypass switch to Operate. If the Bypass mode was interrupted by an Emergency Stop or a Power Interrupt as indicated on the front panel, the Reset button must be pressed in order to resume operation. (see previous ***Warning***)

3.4 Operate Mode

The **Operate** mode is entered from the Reset mode with the Operate/Bypass switch set to operate by actuating the Start button. When the Start button is pressed the yellow Start light illuminates indicating that the output is no longer compressed. After the acceleration has exceeded the selected Lower limit for approximately 300 mSec the green Run light will illuminate.

In the operate mode the unit monitors both the acceleration and displacement of the test specimen and displays the Peak or RMS values on the front panel meters. These values are compared to those set on the pushwheel limit set switches and a shut down is initiated if an out of limit condition (fault) is detected. The limit pushwheel switches may be adjusted in the operating mode but care must be taken so as not to have limits set either instantaneously excessively high or low while making the adjustment. Please also note that 4.99 inches (49.9 mm) and 499 g's (49.9 when 100 g range is selected) are the maximum RMS settings allowed. Moving the pushwheels to a setting exceeding this during RMS operation will cause a fault.

The Operate mode can also be terminated and the output compressed by pressing the Reset button, however, acceleration and displacement data will be lost.

3.5 Fault Mode

When a fault is detected soft shut down is initiated and the offending acceleration or displacement value is flashed on the appropriate digital display. The other display is frozen at it's reading at the time of the fault and the red **Fault** indicator is illuminated. Should a fault occur as a result of a change in the front panel settings (other than the limit or gain adjustments) both displays will be locked at their last values and a fault indicated. This will also be the case if the fault is the result of an Emergency Stop, an external interlock, or a Power interrupt except that the appropriate red Emergency Stop or Power Interrupt indicator will be illuminated.

The fault mode may only be exitted by pressing the Reset button. Before resetting the fault, the Operate/Bypass switch should be checked to be sure that it is in its desired position. The unit will go directly into the Bypass mode if it is reset with the Operate/Bypass selector set to Bypass (see previous ***Warning***).

3.6 Operation Examples

Example #1

A four hour test is to be run using a servo-controlled sweep from 20 to 2000 Hz and limited by a .25" (6.4 mm) maximum displacement and a maximum acceleration of 50 g's. It can therefore be calculated that a minimum acceleration of 5.11g will be required for .25" (6.4 mm) at 20 Hz. (Note: Acceleration of less than this minimum would indicate a loss of signal or other system malfunction.) Allowing for approximately a 10% error the upper acceleration limit is to be set at 55 g's, the lower acceleration limit to 4.6 g's, and the maximum displacement to .28".

With the power on and the unit properly calibrated, the following sequence is performed to set up the test monitor:

1- Set The **Operate/Bypass** selector to **Operate**.
2- Press the **Reset** button.
3- Set the **Range Selector** to 100 g's. This provides a full scale reading of 99.9 g's for acceleration and similarly fixes the decimal point for the acceleration limit settings. (Note: There is a one to one correspondence between the digital displays and the corresponding pushwheel limit switches as determined by the Range setting, 99.9 g's full scale on the display corresponds to 99.9 g's full scale on the limits and 999 g's full scale on the display corresponds to 999 g's full scale on the limits.)
4- Set the **Peak/RMS** selector to **Peak**.

5- Set the upper acceleration limit to 50.0 g's by adjusting the three corresponding pushwheel switches to 5, 0, and 0.
6- Set the lower acceleration limit to 04.6 g's by adjusting the three corresponding pushwheel switches to 0, 4, and 6.
7- Set the maximum displacement limit to 0.28" (07.1 mm) by adjusting the three corresponding pushwheel switches to 0, 2, and 8 (0, 7, and 1).
8- Insure that the system gain is turned down and press **Start**.
9- Observe the yellow **Start** indicator and begin the test as usual.
10- Upon completion of the test, shut down may be accomplished by pressing **Emergency Stop** or **Reset**. If desired, the lower limit may be adjusted to 00.0 (in order to avoid an under acceleration fault) and the system shut down normally. When this is done, the yellow indicator remains illuminated and the output is not compressed until a fault or a reset occurs.

Example #2

A test is being set up and initial tests are to be performed in order to check fixturing, etc. but in no event should the test specimen be subjected to more than 200 g's. Under acceleration (loss of signal) and over displacement will not be monitored during these initial tests and are to be disabled.

With the power on and the unit properly calibrated, the following sequence is performed to set up the test monitor:

1- Set The Operate/Bypass selector to **Operate**.
2- Press the **Reset** button.
3- Set the **Range Selector** to 1000 g's. This provides a full scale reading of 999 g's for acceleration and similarly fixes the decimal point for the acceleration limit settings.
4- Set the **Peak/RMS** selector to **Peak**.
5- Set the upper acceleration limit to 200 g's by adjusting the three corresponding pushwheel switches to 2, 0, and 0.
6- In order to disable the lower acceleration limit, set it to 000 g's by adjusting the three corresponding pushwheel switches to 0, 0, and 0.
7- Set the maximum displacement limit to 9.99" (99.9 mm) by adjusting the three corresponding pushwheel switches to 9, 9, and 9.
8- Insure that the system gain is turned down and press **Start**.
9- Observe the yellow **Start** indicator and begin the initial testing.
10- Upon completion of the test shut down may be accomplished by pressing **Emergency Stop** or **Reset**.

SECTION 4
INSTALLATION AND CALIBRATION

4.1 Power Requirements

The TAP-1000 is designed to be installed in a standard 19" rack panel arrangement and unless specifically ordered and labeled otherwise requires ***115 VAC 50/60 Hz*** power for which a power cord is provided. The unit may be converted for 230 VAC 50/60 Hz operation by removing the top cover, locating the switch labeled **S3** on the main circuit board, and positioning it to the 230 VAC setting. The power cord supplied can then be modified or replaced as desired.

4.2 Displacement Display Units

The TAP-1000 can be configured to display either **9.99 inches or 99.9 millimeters** full scale displacement. Please note that the pushwheel limit settings are correspondingly either inches or millimeters depending on the configuration of the display. If the configuration of unit supplied was not specified when ordered, or if modification is desired, use the procedure that follows:

1- Remove the top cover and locate the two position dip switch on the main Board labeled **S1**.

2- In order to display inches or millimeters both positions of **S1** should be set to "english" or "metric" as indicated on the silkscreen (both ON = english).

3- Locate the two position dip switch on the back side of the front panel printed circuit board [S10]. One position of this dip switch should be "ON", corresponding to "english or metric" as indicated in the etch of the circuit board, and the other position should be "OFF". These switches control the position of the decimal place of the digital displacement display. The least significant digit for "english" is always .01" and for "metric" is 0.1 mm.

Fig 4-1A
Using the Input Amp as the system charge amplifier and TAP-1000 input

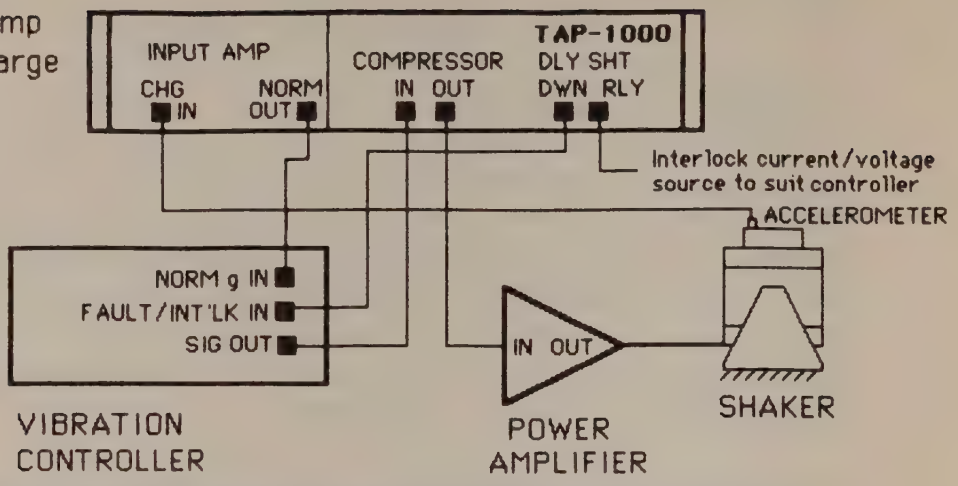


Fig 4-1B
Using the Vibration Controller charge amplifier to monitor accelerometer input

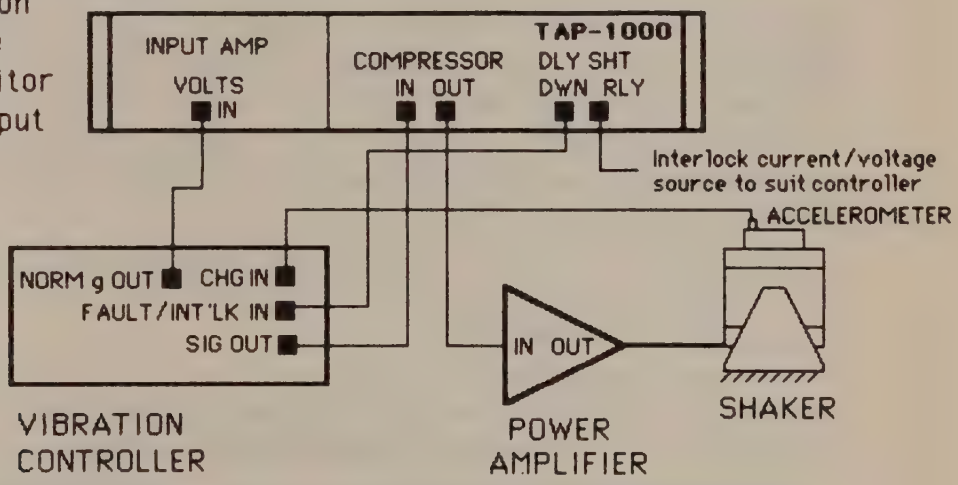


Fig 4-1C
Using a seperate monitor Accelerometer for protection.

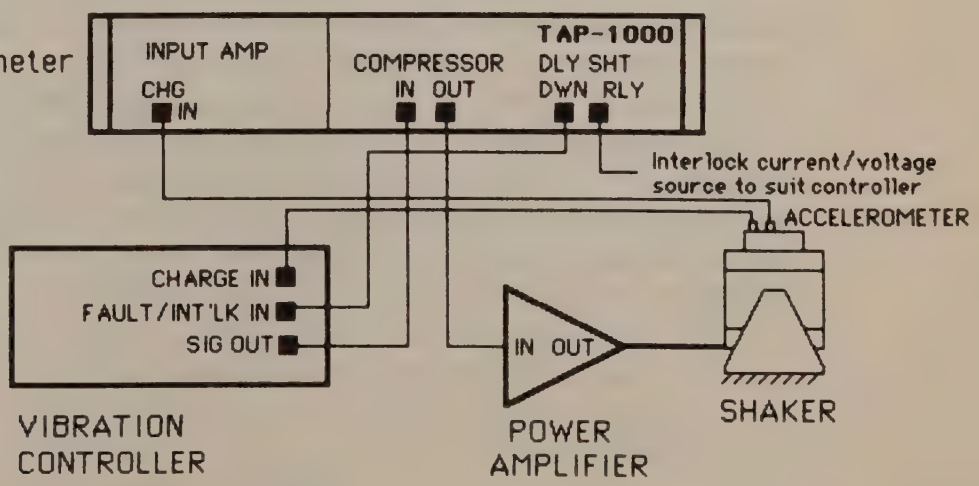


FIGURE 4-1
Basic System Interconnection Examples

4.3 Accelerometer Sensitivity Adjustment

It will be necessary to make sensitivity adjustments in order to correct for differing accelerometer outputs. This adjustment is made as follows:

1- With the unit set for peak to peak Bypass operation and the accelerometer properly connected to J2 on the rear panel, subject the accelerometer to a known sinusoidal acceleration and displacement.

2- Unlock the front panel Sensitivity knob and adjust it so that the digital displays provide the appropriate acceleration and displacement readings. If the sensitivity cannot be adjusted so that both the acceleration and displacement readings are satisfactory calibration of the unit itself will be required.

4.4 Calibration/Alignment Procedure

This instrument was calibrated prior to shipment, however, adjustments may be necessary from time to time in order to insure the accuracy of the unit. Should adjustment be necessary follow the procedure outlined below.

Assignments:

P1	Disp. pk. offset	GND	for ref measurements, left side when viewed from the rear of the instrument
P2	Disp. rms offset		
P3	Accel. A/D offset		
P4	Accel. A/D gain	TP1	Disp. rectifier output
P5	Disp. A/D offset	TP2	Disp. rms det. output
P6	Disp. A/D gain	TP3	Accel. rectifier output
P7	Accel. pk. offset	TP4	Accel rms det. output
P8	Disp Calibration	TP5	Disp. voltage gen. output
P9	Accel. rms offset	TP6	input Acceleration voltage

4.4.1 Equipment Requirements:

- AC voltmeter, 100kΩ/volt min., .5% acc, rms calibrated
- DC voltmeter, 100kΩ/volt min., .5% acc, .1 mV resolution
- Dual channel oscilloscope, DC coupled
- Sine wave signal generator, 1V rms min output, DC coupled 13-70 Hz min.
- Shorted BNC male plug
- Small slot blade trim pot adjustment screw driver
- 5/64" hex Allen wrench

4.4.2 Procedure:

1- Remove the top cover from the TAP-1000.

2- Set the **Input** mode switch [S3] the rear panel for voltage input. With the **Transducer Current** source switch [S1] on the rear panel off, set the **Input Range** switch [S2] to 10-110, and the internal high output voltage DIP switch on the Input Amplifier circuit board to "on". On the main PCB, set S1 for English units (both "on"), then set the front panel **Sensitivity** adjustment fully clockwise to 11.0, range switch to 100g and the detector switch to "Peak".

3- Connect a shorted BNC connector to the Voltage Input on the rear panel and turn the power switch [S4] on the rear panel to "on". Wait a minimum of 10 minutes before continuing this procedure to allow the circuit to stabilize.

4- Connect the (-) side of a DC voltmeter to the ground point provided on the main PC board.

5- Adjust trimmer P9 to give a 0 ± 1 mV reading at TP4.

6- Adjust trimmer P2 to give a 0 ± 1 mV reading at TP2.

7- Adjust trimmer P7 to give a 0 ± 1 mV reading at TP3.

8- Adjust trimmer P1 to give a 0 ± 1 mV reading at TP1.

9- Press the **Reset** button on the front panel.

10- Null trimmer P5 to give the minimum displacement front panel reading (00.0 ± 00.1).

11- Null trimmer P3 to give the minimum acceleration front panel reading (00.0 ± 00.1).

12- Remove the shorted BNC connector and connect a sine wave signal generator to the **Voltage Input** BNC [J1] on the rear panel. Also connect an AC voltmeter to the **Normalized Voltage Output** BNC [J4] on the Rear Panel.

13- Set the signal generator for 50-70 Hz and apply a 1-3 V sine wave to the input amplifier.

14- Adjust the front panel sensitivity control to give a normalized output voltage of 6.36 ± .01 Vrms at the Input Amplifier.

15- Adjust trimmer P4 to give a front panel acceleration reading of 90.0 ± .2 g.

16- Holding the signal generator amplitude constant, reduce the input signal frequency to 14.0 ± .1 Hz.

17- Adjust trimmer P8 to give 6.4 ±.05 Vac on TP5. An AC voltmeter can be used for this adjustment if it is capable of accurate measurements at 14 Hz.

18- Increase the frequency to approximately 50 Hz and reduce the input signal voltage to give 0.883 Vac at the charge amplifier normalized out connector.

19- Reduce the signal frequency to 7.00 ± .02 Hz holding the signal input amplitude constant. Adjust trimmer P6 to give a front panel displacement reading of 5.00 in p-p.

20- If large adjustments were required during the calibration, it may be necessary to repeat steps 5-18 a second time to insure maximum accuracy.

21- Turn the TAP-1000 off, disconnect all test equipment and replace the top cover.

SECTION 5
TAP-1000 THEORY OF OPERATION

Reference drawing #108007

5.1 Reference Symbols

In the following circuit descriptions:

- capacitor references are denoted by a preceding "C".
- resistor references are denoted by a preceding "R".
- test point references are denoted by a preceding "TP".
- trim potentiometer references are denoted by a preceding "P".
- transistor references are denoted by a preceding "T".
- diode references are denoted by a preceding "D".
- plug and jack references are denoted by a preceding "J"
- IC references are denoted by a preceding "U" with a "-X" pin number to denote a particular device within an IC package.
- reference designators in lower case signify front panel components
- references to the system microprocessor Bus and Ports will use "bussX","port1X" or "port2X" for the Buss, Port1 and Port2 respectively where "X" represents the particular bit of interest, numbered 0 to 7.
- The system microprocessor, U5, is labeled "Micro" for brevity

5.2 Analog signal conditioning

The input acceleration signal comes from the Input Amplifier section through J4-9. The DB style connector at J4 supplies all of the necessary voltages and sensitivity control connections required by the Input Amplifier. The output acceleration signal from the Input Amplifier is normalized to 100 mV/G for system use and is applied to the TAP-1000 acceleration rms detector and the acceleration peak detector through C8. The acceleration rms detector U18 is an AD536A. It is AC coupled through C70 and has a zero offset adjustment at P9. The output voltage of the acceleration rms detector is available at TP4 and is routed to the acceleration A/D converter data selector switch U11. The output of the acceleration rms converter is scaled by a resistive voltage divider to provide the proper voltage range for the 3162 A/D converter.

True peak detection is provided by U16 for acceleration. AC coupled through C9, U16-8 acts as a precision full wave rectifier in conjunction with U16-14. The rectifier offset voltage is trimmed at P7 and the output voltage is available at TP3. U16-1 forms a precision peak detector operating on the rectified signal from U16-14 and the peak voltage is stored on C5. The acceleration peak voltage buffered by U16-7 has a long

time constant to increase A/D conversion accuracy. To enhance the system response, the charge stored on C5 is released (reset) on command from the micro, U5, by conduction of T3. This FET transistor is driven by voltage converter T4 for gate operation between -15 volts and +5 volts and is in turn driven by the micro through J2-4.

The DC proportional to peak voltage on C5 is buffered by U16-7 and is scaled by voltage divider R32 and R31. This voltage is routed to the analog data switch U11 for application to the acceleration A/D converter.

The acceleration voltage from the input amplifier is wired to the displacement voltage generator through displacement calibration trimmer P8. A resistor/diode divider bias the displacement voltage generator section to approximately +.6 V above signal ground to forward bias coupling capacitors C9, C70 and C19. U17-7 forms an acceleration voltage buffer and gain of 10 amplifier for 100g/1000 g front panel ranging. Switching R45 out of the op-amp feedback loop by use of the analog switch U12 provides an acceleration signal scaled up by a factor of 10 for 1000 g operation (10 mV/g from the Input Amplifier).

The displacement voltage is generated directly from this acceleration voltage by a 2-pole Chebyshev low pass filter with cut-off frequency at approximately 2.5 Hz. This filter is formed by U17-1 and its associated resistor/capacitor network, and is designed so that the AC output voltage will be one-half the input voltage to the filter at approximately 14 Hz with a sinewave input. To increase low frequency stability, the low-pass filter is followed by a 2-pole Chebyschev high pass filter with pass gain of 2 and cut-off frequency at approximately 2 Hz. which limits the very low frequency (<4 Hz) voltage generated. This high pass filter is made up of U17-14 and associated components. The combination of filters yields unity gain for the displacement voltage generator at approximately 14 Hz. The output of this section is available at TP5, and is the displacement voltage used for the displacement detection circuitry.

The displacement voltage is applied to the displacement rms detector and the displacement peak detector through C2 and C3. The rms detector, an AD536A at U10, can be trimmed for zero offset voltage by trimmer P2, and its output voltage is available at TP2. The DC voltage is scaled for use by the A/D converter by the resistor divider R11 and R7 and is further routed to the U11 data selector. The rms acceleration divider network contains switch S1 and R8. Closing or opening this switch provides the appropriate scaling for English or Metric displacement front panel display and comparison.

The displacement voltage is applied to the its peak detector through R13

to a precision rectifier made up of U1-8 and -14 with zero offset trim provided by P1 and output voltage available at TP1. This rectifier is also followed by a precision peak detector at U1-1 which stores the peak voltage equivalent to the displacement peak on capacitor C1.

This DC voltage is buffered by U1-7 and is put through the voltage dividing network of R12 and R10 which scales the output voltage for the A/D converter as well as the double amplitude displacement requirements of sine operation. R9 in conjunction with S1 also scales the peak displacement voltages to Metric or English displacement units. The output voltage from the divider network is routed to the analog data selector at U11 for routing to the displacement A/D converter. The displacement peak detector also utilizes a long time constant for consistent readings with reset pull down upon micro command through R5 and T1.

5.3 Digital signal processing

By action of the front panel switch (PK/RMS) the appropriate signals are routed through U11 to the displacement and acceleration A/D converters U8 and U7 respectively. These A/D converters are identical and utilize P5 and P3 respectively to set the zero signal offset and P6 and P4 to trim the A/D conversion gain. The output of the A/D converters is sequential 3 digit information coded in BCD format and is multiplexed in time. The BCD information is available from both A/D converters on pins 16,15,1 and 2 with the appropriate significant digit identifier information available on pins 4,3 and 5. The output of the 3162 A/D is open collector and is pulled up by resistor packs RP1 and RP2. These digital signals are fed into a pair of LS257 's for multiplexing to the micro. The BCD information is selected by U3 and the significant digit identifier is selected by U2.

This arrangement allows the micro to read either the acceleration or the displacement A/D's by raising or lowering its port17 line. A low voltage on this line will provide displacement BCD information on port10-port13 and displacement significant digit identifier information on port14 -port16. Raising port17 supplies this same information to the micro using the acceleration A/D converter as its source. This allows the micro to get an instantaneous reading from either the acceleration or displacement A/D converter on demand.

5.4 Microprocessor input

The serial communications identifier code is generated by S2 and pulled up by R70-73 . This code is applied to latch U4, bits 4-7. Inputs from the front panel toggle switches; Range, PK/RMS, LOCAL/REMOTE and BYPASS are brought to the micro through U4 latch bits 0-3 respectively.

The RESET button status is presented to the Micro from the front panel through J2-10 and applied directly to the micro's reset input pin 4. STOP button status is poled via J2-9 and applied to the micro's interrupt line directly. START front panel button information is brought into the micro by J2-8 and applied to the micro's T0 monitor input.

Thumbwheel switch information is gathered by the micro on the thumbwheel data lines at J3-9 to -12 with all thumbwheel switches diode-matrix wired onto the common data lines. These lines are held high by the address generator and are pulled down through the thumbwheel switch common pins on command from the micro. In this manner, each thumbwheel switch is sequentially activated and its setting is read on the thumbwheel switch data lines. Activation of thumbwheel switch S9 also enables latch U4 located on the main board via J2-15 to enable the front panel toggle switch information and the serial communications assignment code to be present on the port1 data buss for reading by the micro.

For low frequency sine detection time compensation, an input signal zero crossing detector is used to detect signal frequency. This circuit utilizes a comparator made up of U17-8 whose output is limited to logic levels by D8, inverted by U13-6 and applied to the micro's input monitor T1 input U5-39. The inverting input to this comparator is wired to the acceleration voltage through R53 and the non-inverting input is wired to the system displacement voltage. Taking advantage of the 180° phase relation between displacement and acceleration insures a strong zero crossing signal at all frequencies.

5.5 Microprocessor output

All of the front panel readouts and LEDs are selected using an address generator formed of u7, a 74154. The desired address is presented to the address generator through J3-5 to -8 and the individual addresses generated correspond to the listing on drawing 108007, sheet 2. These address codes are generated at the micro on buss0-buss3 with the appropriate data presented to the micro at port1. This data information is feed to the front panel by J3-1,3,16,14,13,15,4 and 2. This is a bi-directional data buss with digital display information being sent to latches u1,u2 and u3. Power interrupt, emergency stop indicator lights and various other functions are controlled directly from the address generator u7. The micro functional output lines are driven by the micro buss4 to buss7.

Buss bit 4 controls the SHUT-DOWN function which activates the

shut-down and delayed shut-down relays when a fault occurs. Driving the front panel fault LED through J2-13, the shut-down line is also buffered and inverted by U14 and applied to T8 for actuation of the relay circuitry. The shut-down relay coil is driven by T9 and coil flyback current is shunted by D23. An approximate 500 ms. time delay is formed by R90 and C31. The delayed voltage drives the darlington transistor pair T10 and T11 to switch the delayed shutdown relay.

The optically isolated compressor circuitry is controlled by the micro through buss5 on the micro. The compressor circuit is active (shut down or compressed) when the bit voltage is high. This voltage is inverted by U14-6 before application to the compressor circuitry. There are three components to the TAP-1000 compressor section; the optically isolated compressor circuit, a relay compressor clamp circuit and the start relay and indicator driver circuitry. Depressing the front panel start button when the TAP-1000 is not in the by-pass mode will immediately apply voltage to the compressor circuit T5. A high logic voltage on this transistor shuts off the drive current to the three photo-resistor/LED optical isolators, driving the optical isolator resistor resistance high. Simultaneously, the high logic voltage applied to T6 and T7 darlington pair causes immediate switching of relay RLY1. This switching releases the short across the compressor output line and connects the compressor output to the compressor input through the common relay contacts. Relay RLY2 is also switched to provide rear panel contact switching with the compressor status.

When a fault condition is detected, the micro issues a logic high from its buss5 which is inverted by U14-6 to turn T5 on. The resulting high current surge from the charge stored on C29, through the parallel LED's insures rapid lowering of the optical coupler parallel resistance to act as an exponential voltage divider with R59 which provides a decreasing compressor output signal amplitude. After approximately 25 ms the dissipated charge from C6 will no longer drive T6 &7 and RLY1 switches to remove the input drive signal from the compressor output and in turn connects the output to the compressor common (ground) line to form a short at the output jack. The rear panel start relay contacts and the front panel start indicator light are also switched at this time.

The micro buss6 is used to enable the A/D converters to the port 1 data bus as discussed earlier.

When the system LOWER LIMIT criteria has been satisfied, the micro issues a contact closure and lights the front panel run light using its buss7. Buffered and inverted by T12, the voltage is applied directly to the back panel lower limit relay coil.

5.6 Back panel

Back panel inputs include hard wired bypass, start and reset lines. Raising J9-22 (start) or J9-23 (reset) to +5v will initiate the respective function. Single pole momentary switches may be implemented by utilizing the +5v available on the back panel J9-24. These inputs are protected by Zeiner diodes D16 and D17 and inverted by U14-10 and -12. the outputs of the inverters are wire and diode OR'ed to the micro input pins. The bypass terminal J9-3 is held to +5V J9-24 for bypass operation and is less than 0.8V or disconnected for normal operation.

An external interlock circuit is provided which emulates the front panel STOP push button to provide external series (fault open) and parallel (fault closed) interlock capability. The removable jumper at X8 satisfies the interlock when not in use and must be removed prior to fault open interlock implementation. The voltage at the interlock input J9-8 should be high in the interlock "OK" condition and grounded or low in the faulted condition. This input is Zeiner protected and wire OR'ed to the micro's interrupt terminal U5-6.

5.7 Serial communication

The external serial communications are handled by a pair of optical isolators in an independent isolated circuit made up of U19 and U20. D21 provides static over voltage protection. In the high logic state, the circuit draws approximately 3 mA of current from the communications line through the LED in U19. This causes the U19 transistor to conduct which pulls the input line to U13-8 and U13-11 gates to the low logic state. U13-8 is wired as an inverter and the true input information is routed to the micro port27 for detection. To facilitate handling of the incoming information interrupt, the communications interrupt through U13-11 can be disabled by the micro at port24. Outgoing communications are controlled by micro port25. A logic low at this pin causes conduction of the LED in U20 which in turn clamps the communication line through T14 to give a communication line logic 0.

5.8 Power Supply

The TAP-1000 power supply utilizes standard linear techniques to provide 4 regulated DC output voltages and a line voltage detector. Switch S3 will parallel or series the power transformer's primary windings to provide for 115 VAC or 230 VAC input line voltage. The input line filter X3 reduces the conducted emissions as well as shields the TAP-1000 from line born noise. The power supply provides +15 and -15 VDC referenced to signal

ground for use by the analog circuitry. It also provides for two independent +5 VDC supplies for use by the digital circuitry. The micro, charge amplifier, interlock logic and compressor circuitry operate from a separate regulator fed by a large storage filter capacitor C32. This capacitor allows the micro and related circuitry enough time during power interrupt or power fault to provide for an orderly shut-down sequence. Should the power be restored within 1 to 2 seconds, the micro remains functional and the operating levels prior to power line fault will be displayed along with a power interrupt fault indication on the front panel.

A second, high current +5V supply is used to supply all other logic and readout requirements. A power line voltage detector line is pulled from the power transformer 15 v secondary winding and detected and conditioned by R74, D10 and D11 to form a power interrupt detector. The detect time is determined by the combination of C26 and R65 and is approximately 16 ms. Once detected, inverter U14-4 charges capacitor C27 and through U14-2 is diode OR'ed to the micro's interrupt pin and tied directly to the micro's port26 for interrupt source detection.

5.9 Input Amplifier

The Input Amplifier is made up of three sections; the charge amplifier, the voltage amplifier and the output amplifier.

5.9.1 Charge Amplifier

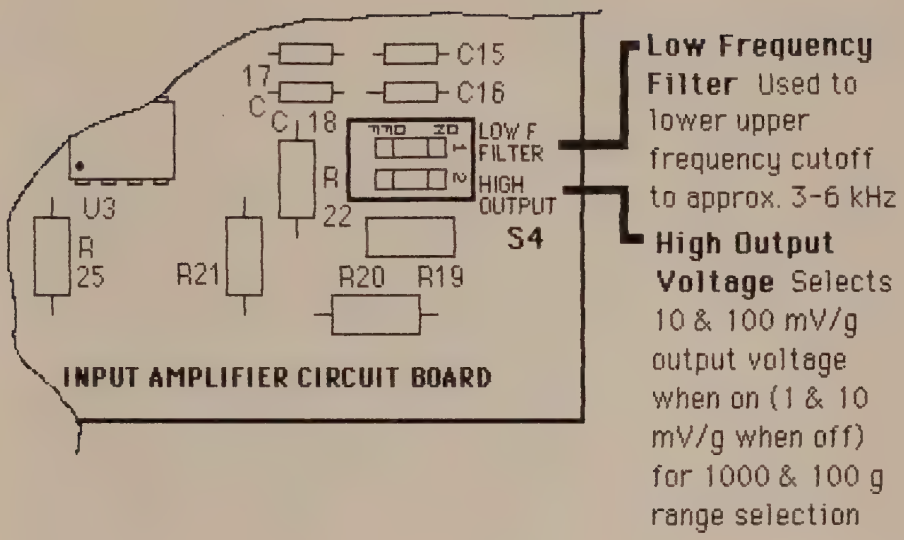
The charge amplifiers' input is through the J2 BNC mounted on the rear panel. Input charge signals are converted to voltage by the FET high impedance op-amp U2-1. To provide for various combinations of input charge sensitivity as well as output range scaling, three different feedback capacitors can be switched into the integrator circuit. Sensitivity range is controlled by panel switch S2 labeled SENSITIVITY. Range scaling, typically host generated, is switched by an analog DPDT switch at U1. The output of the integrator is routed by the mode selector switch S3 (in the pC/g position) to the SENSITIVITY potentiometer (usually mounted on the host front panel). The wiper return of the sensitivity potentiometer provides the feedback loop voltage and is buffered by voltage follower U2-8. The "T" low pass filter network of R12,13 and C7 and 8 provide DC stability damped by R14. The main feedback path is routed through the analog range switch U1-5 and U1-9 to allow selection of the proper feedback capacitor. Parallel combinations of C9-10, C11-12 and C13-14 form the three decade capacitors required for the charge amplifier integrator. When mode switch S3 is in the mV/g mode the charge integrator output is routed to its own inverting input to prevent oscillation when not in use.

5.9.2 Voltage Amplifier

The voltage amplifier takes its input through J1 BNC on the Input Amplifier panel. This input is referenced to ground by R2 and capacitively coupled for 5 Hz by C1 and C2. To facilitate use of resistive type acceleration transducers, a constant current source is provided at the input and can be switched into the circuit by S1. The current adjust trimmer is available at the panel and can be adjusted from 0 to approximately 25 mA. Ziener diodes D1 and D2 protect the voltage input against over voltage conditions in conjunction with R5. Input voltage sensitivity range is controlled by shorting R7 with the Sensitivity switch S2. The output of the voltage amplifier U2-14 is routed through the mode switch S3 (when it is in the mV/g position) to the sensitivity potentiometer for system calibration. The feedback return from the sensitivity control is buffered by U2-8 and routed through feedback resistors R8 and R9 to the inverting input of the voltage amplifier. Range scaling is accomplished by shorting R8 in the feed back path by the analog switch U2-16 to U2-1. When mode switch S3 is in the pC/g mode the voltage amplifier output is routed to its own inverting input to prevent oscillation when not in use.

5.9.3 Output Amplifier

The output amplifier gets its input from the output of either the charge converter or voltage amplifier op-amp outputs by tapping the sensitivity output line. The resistor divider R17 and R18 reduce the input voltage to 1/2 in preparation for application to the 2-pole high pass Chebyshev filter with gain of 2 and cutoff frequency of approximately 3 Hz. The upper end of the frequency spectrum is limited by the single pole filter created by C15. To lower the high frequency response, C16 can be switched into the circuit using the DIP switch, S4-1, located at the rear of the Input Amplifier PCB (Ref. Fig. 5-1). This switch will bring the upper cutoff frequency down to the 3-6 K Hz range. The overall pass band gain of this section is unity which yields the nominal 100 mV/g routed through the output connector to the host. To facilitate 10 mV/g external system requirements, the divider R26 and R27 may be activated by opening S4-2 (Ref. Fig. 5-1) on the Input Amplifier PCB. The NORMALIZED voltage output is buffered at either 10 mV/g or 100 mV/g in the 100g host front panel range (depending on the position of S4-2), and presented to J4 BNC connector on the Input Amplifier panel. Pulling the input range pin J3-8 to logic high (>+3V) reduces the output voltage to 1 mV/g and 10 mV/g respectively.



Input Amplifier Printed Circuit Board
FIGURE 5-1

SECTION 6
DOCUMENTATION

6.1 PURPOSE

All documentation needed to support this product are included on the following pages.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	TM-108 Test Monitor 108000 3/11/88											Serial No. 196 and Up		Tot.
2		Description					Qty.					Ref. Desig.	Part *	Qty.
3	TM-108 Test Monitor						001-							
4		Complete Assy						001-					108000-1	
5			Charge Amp, Model IA-110						001-				110000	1
6			Front Panel						001-				108003	1
7			Shell						001				108004	1
8				Silkscreen						001			108009	1
9			Top						001				108005	1
10			Bottom						001				108012	1
11				Top						001			108005	
12			Molding						002-				108006	2
13			Front Panel Overlay (Ling)						001-				108010	1
14				Front Panel Art									108010-1	
15				Die Cut Shape									108010-2	
16														
17			Cable Assem., 8 Ft., 10A, 125V, Black						001				135-00001	1
18			Cable, 16 Pin Dip, Jumper						002-				108017	
19				Flat IDC Cable, 16 Cond, 28 AWG						0.6'			132-00016	1.2
20				IDC Conn., 16 Pin, DIP Plug						002-			253-00001	4
21			Cable , 2 Cond Shielded						002'				133-00002	2
22			Potentiometer 10K, 10 Turn, Panel Mount						001-				572-A0103	1
23			Dial, 15 turn, 1/4" Shaft, W/Lock						001-				371-00004	1
24			Resistor, 1.00K, 1/4W, 1%						001-				571-N1001	1
25			Sheet Metal Screw, #6 X 1/4, P.H.						014-				336-HXB02	14
26			Nut, #10-32						004				333-NAB00	4
27			Machine Screw, 4-40 X 1/4, S.H. Binder						004-				331-FPA02	4
28			Nut, #4-40						004-				333-FAA00	4
29			Ring Lug, Swage type, 18 Awg X #6 Stud						003-				660-00003	3
30			Wire, Black PVC, Multistrand #18 AWG						0.7'				131-0BP18	0.7
31			Machine Screw, 6-32 X 3/8, P.H. Binder						016-				331-HXB03	16
32			Nut, #6-32 Reg, Cad Plat Stl						006-				333-HAA00	6
33			Standoff, PC Board, 3/4", Plastic Snap Type						006-				461-00004	6
34			Standoff, #6-32 X 1" X 1/4" O.D., Round, Alum.						008-				461-00006	8
35			Washer, Nylon, .156 ID X .312 OD X .062 thk						008-				337-00002	8
36														
37		Main PCB assembly						001					108013	
38			Main PCB						001				108008	1
39			Jack, Power Line						001-			J10	250-00001	1
40			Plug, BNC, Insulated						003-			J6,7,8	250-00002	3
41			9 Pin DB type Female, Rt Angle						001-			J4	251-00020	1
42			Socket, IC, 14Pin, Gold Mach. Con.						005-			RLY1 - 5	460-00001	5
43			Socket, IC, 16 Pin, Gold Mach. Con.						002-			J2,3	460-00002	2
44			Socket, IC, 40 Pin, Gold Mach. contacts						001-			U13	460-00007	1
45			Plugable Horizontal PCB , 24 Position Hdr						001-			J9	662-00006	1
46			Plug 24 Position						001-			J9	662-00007	1
47			Relay, SPDT, 5V						005-			RLY1 - 5	561-00001	5
48			Opto coupler, Clarex #CLM6500						003			X5,6,7	394-00005	3
49			Test Points, Loop Type, Pink						007-			TP1-7	462-00002	7
50			Header 2 Pin						.06-			X8	252-00001	0.1
51			Shunt .100" Centers						001-			X8	462-00003	1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
52						Switch, DIP, 2 Position			001-			S1	631-00002	1
53						Min. Rotary Coded Dip Switch			001-			S2	635-00001	1
54						SPDT 2 POS Min. toggle, Rt angle			001			S4	638-00006	1
55						Slide Switch, DPDT, Miniature PC Mount			001			S3	640-00002	1
56														
57						Power Line Filter,PCB Mount			001-			X3	321-00001	1
58						Fuse, Pigtail, 3Amp			001			X4	362-00001	1
59						Crystal, 6.0000 MHz, .01%			001-			X1	500-00002	1
60						Transformer, ±15 & 5V			001			X2	691-00003	1
61														
62						HI3-5043-5 Cmos Analog Switch, 2XSPDT			002-			U11,12	390-5043-	2
63						AD536AJH Rms/DC Converter			002-			U18,10	391-00002	2
64						CA 3162 E, 3 Digit BCD A/D Converter			002-			U7,8	391-00003	2
65						IC, Quad Op-Amp TL084CN			003			U1,16,17	392-00004	3
66						D 8749 H, Microprocessor 8 Bit			001-			U5	393-00002	1
67						TIL117 Optical Coupler			002-			U19,20	394-00003	2
68						74 C 373 N Octal D Latch			001-			U4	395-C373N	1
69						74 LS 000 Quad 2 Input Nand			001-			U13	395-LS000	1
70						74 LS 014 Hex Schmitt Inverter			001-			U14	395-LS014	1
71						74 LS 257 Quad Data Selector			002-			U2,3	395-LS257	2
72						Voltage Regulator, +5 Volt, *7805			002-			U6,9	396-00001	2
73						Voltage Regulator, +15 Volt, *7815			001			U15	396-00003	1
74						Voltage Regulator, -15 Volt, *7915			001			U21	396-00004	1
75						Heat Sink, Aavid 5510B			001-			U9	375-00002	1
76														
77						Diode, 1N914			015-			D1-7,12-15,18,19,34,35	291-00001	15
78						Diode, 1N4001			014-			D9,11,22-33	291-00002	14
79						Zener Diode, 3.6V, 1N5227, 1/2W			001-			D8	293-0A036	1
80						Zener Diode, 5.1V, 1N5231, 1/2W			002			D16,17	293-0A051	2
81						Zener Diode, 5.6V, 1N5232, 1/2W			002-			D10,20	293-0A056	2
82						Zener Diode, 6.8V, 1N5235, 1/2W			001-			D21	293-0A068	1
83														
84						Transistor, NPN, 2N3904			003-			T6,10,13	702-00001	3
85						Transistor, PNP, 2N3906			003-			T2,4,8	702-00002	3
86						Transistor, PNP, 2N2905			002-			T5,12	702-00004	2
87						Transistor, NPN, 2N2219			004-			T7,9,11,14	702-00005	4
88						Transistor, PNP, 2N4857			002-			T1,3	702-00006	2
89														
90						Potentiometer, Trim, 1/4 W								
91						Trim Pot 10K Vertical			002-			P4,6	575-A0103	2
92						Trim Pot 20K Vertical			002-			P1,7	575-A0203	2
93						Trim Pot 50K Vertical			004-			P2,3,5,9	575-A0503	4
94						Trim Pot 100K Vertical			001-			P8	575-A0104	1
95														
96						Resistor Pack, 10K X 7, 8 Pin Sip			002-			RP1,2	574-00001	2
97														
98						Capacitor, Monolythic Ceramic, Epoxy dip								
99						Capacitor, 5pF, 50V, 20%			001-			C24	160-BB050	1
100						Capacitor, 22pF, 50V, 10%			001-			C23	160-AJ220	1
101						Capacitor, .1uF, 50V, 20%			004-			C12,13,22,28	160-A8104	4
102						Capacitor, .27uF, 50V, 10%			003-			C14,15,21	160-BJ274	3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
103						Capacitor, .56uF, 50V, 5%			003-			C16,17,18	164-CE564	
104														
105						Capacitor, Electrolytic								
106						Capacitor, 2.2uF, 16V, 20%			002-			C30,36	163-AC22A	2
107						Capacitor, 4.7uF, 6V, 20%			001-			C25	163-AA47A	1
108						Capacitor, 4.7uF, 16V, 20%			004-			C4,6,7,11	163-AC47A	4
109						Capacitor, 10uF, 16V, 20%			003-			C1,5,31	163-AC100	3
110						Capacitor, 33uF, 10V, 10%			001-			C26	163-AU330	1
111						Capacitor, 100uF, 16V, 20%			007-			C2,3,8-10,20,27	161-BC101	6
112						Capacitor, 2200uF, 35V			002-			C34,35	161-CF222	2
113						Capacitor, 4700uF, 16V			002-			C29,33	161-CC472	2
114						Capacitor, 15000uF, 16V, -20/+100%			001-			C32	161-DN153	1
115														
116						Resistor, 1/4 Watt 5% Carbon film									
117						33 OHM			003			R62,63,64	571-B33.0	3
118						51 OHM			003			R5,28,85	571-B51.0	3
119						200 OHM			005-			R19,39,68,95,96	571-B20.1	5
120						300 OHM			001-			R69	571-B30.1	1
121						510 OHM			007-			R75,76,79,80-83	571-B51.1	7
122						1.0K			013-			R1,21,51,59,65,70-74,77	571-B10.2	13
123												R87,93		
124						1.2K			002-			R97,98	571-B12.2	2
125						2.0K			006-			R6,27,44,78,88,92	571-B20.2	6
126						2.7K			001			R89	571-B27.2	1
127						5.1K			002-			R66,94	571-B51.2	2
128						10K			007-			R4,15,26,35,53,67,99	571-B10.3	7
129						20K			004-			R84,86,90,91	571-B20.3	4
130						30K			001			R61	571-B30.3	1
131						51K			001-			R54	571-B51.3	1
132						100K			002-			R58,60	571-B10.4	2
133						180K			001-			R49	571-B18.4	1
134						200K			005-			R3,20,25,40,47	571-B20.4	5
135						470K			002-			R22,41	571-B47.4	2
136						1.0M			003-			R2,24,52,	571-B10.5	3
137														
138						Resistor, 1/4 watt 1% carbon film									
139						249 OHM			002-			R23,42	571-N2490	2
140						562 OHM			002-			R30,31	571-N5620	2
141						715 OHM			001-			R8	571-N7150	1
142						845 OHM			001-			R9	571-N8450	1
143						1.27K			001-			R7	571-N1271	1
144						1.74K			001-			R10	571-N1741	1
145						4.99K			002			R16,36	571-N4991	2
146						5.11K			003-			R12,29,32	571-N5111	3
147						8.66K			001-			R11	571-N8661	1
148						10.0K			008			R13,14,17,18,33,34,37,38	571-N1002	8
149						11.0K			001-			R55	571-N1102	1
150						39.2K			002-			R46,56	571-N3922	2
151						221K			001-			R45	571-N2213	1
152						274K			001-			R43	571-N2743	1
153						2.0M			002-			R48,50	571-N2004	2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
154														
155						Front Panel printed circuit board Assembly			001					108014	
156						Printed circuit board				001				108002	1
157						Switch, DIP, 2 Pos, 4 Pin				001-		S10		631-00002	1
158						Thumbwheel switch				009		S1-9		637-00002	9
159						Toggle Switch, SPDT, 2 Pos, Ext PC Contacts				004-		S11,12,16,17		638-00007	4
160						Momentary Pushbutton Switch, SPDT				002		S13,14,15		639-00004	2
161						Button Cap, Black .39" Dia (for 639-00004)				002-		S13,14		639-00005	2
162						Button Cap, Red .39" Dia (for 639-00004)				001		S15		639-00006	1
163						Readout 8 Seg, Red, Common Annode				006		X1-6		311-00002	6
164						LED, Red, T 1 3/4, Diffused				005-		X7,10-13		421-00001	5
165						LED, Green, T 1 3/4, Diffused				001		X8		421-00002	1
166						LED, Yellow, T 1 3/4, Diffused				001		X9		421-00003	1
167						Socket, IC, 16 Pin, Gold Mach. Con.				002-		J1,2		460-00002	2
168						Socket, Display, 32 Pos X .6 L.S., Wirewrap				001-		X1-6		460-00015	1
169						Socket, Display, 32 Pos X .6 L.S., Extended leads				001-		X1-6		460-00016	1
170														
171						555 Timer				001-		U12		394-00002	1
172						Misc. IC's, 3161				006		U5,6,8-11		394-00004	6
173						74154 Decoder, 4 to 16 Line				001		U7		395-74154	1
174						74 C373N Octal D Latch				003		U1,2,3		395-C373N	3
175						74 LS 014 Hex Schmitt Inverter				001		U4		395-LS014	1
176														
177						Transistor, NPN, 2N3904				002		T2,3		702-00001	2
178						Transistor, PNP, 2N3906				001		T1		702-00002	1
179														
180						Diode, 1N914				036-		D1-36		291-00001	36
181														
182						Capacitor, Monolithic Ceramic, Epoxy dip									
183						Capacitor, .01uF, 50V, 10%				001		C7		160-AJ103	1
184						Capacitor, .1uF, 50V, 20%				004-		C1-4		160-AB104	4
185														
186						Capacitor, Electrolytic, Radial Leads									
187						Capacitor, 4.7uF, 6V, 20%				001		C5		163-AA47A	1
188						Capacitor, 10uF, 6V, 20%				001-		C6		163-AC100	1
189														
190						Reststor, 1/4 Watt, Carbon film, 5%									
191						220 Ohm				009-		R1,2,7,8,9,11,13,14,16		571-B22.1	9
192						1.0K				004-		R5,10,12,15		571-B10.2	4
193						2.0K				001		R6		571-B20.2	1
194						10K				001-		R3		571-B10.3	1
195						100K				001-		R4		571-B10.4	1
196														
197						Shipping Assembly			001						
198						Box, Shipping				001				481-00003	1
199						Insert, Foam Corners				004-				482-00004	4
200						Bag, plastic				001				480-00003	1
201						Manual, Operators				001					1
202														

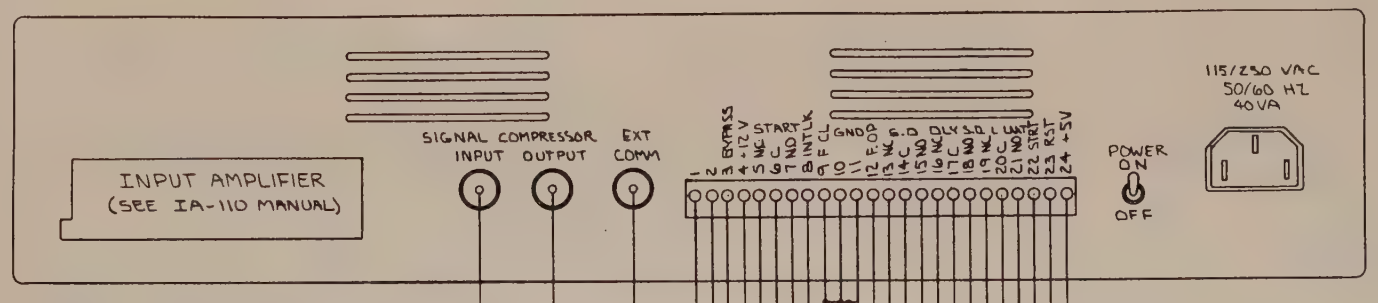
Input Amplifier Bill of Material

	1 2 3 4 5 6	7 8 9 10 11 12	13
1	Input Amplifier	Rev B 12/11/87	
2			
3	Description	Qty. Ref. Desig.	Part #
4	Complete Assembly, Input Amplifier	001-	110000
5	Printed circuit board	001-	110002
6	Face Plate	001-	110003
7	Connector, BNC , Grounded bulkhead	003- J1,2,4	250-00003
8	Connector, DB type, 9 pin, rt angle, plastic, male	001- J3	251-00021
9	Switch, 2 position, DIP	001- S4	631-00002
10	Switch, toggle, 4PDT	001- S2	638-00001
11	Switch, toggle, SPDT	001- S1	638-00003
12	Switch, toggle, DPDT	001- S3	638-00008
13	Screw, #4-40 X 3/8", Phil. Hd. Pan, Black	002-	331-FUB03
14	Nut, #4-40, regular, cad plated steel	002-	333-FAA00
15	Washer, Nylon, .25 OD X .15 ID X .09 thick	004-	337-00001
16	Terminal, solder tab, non insulated, 3/8" stud	001-	660-00002
17			
18	IC, Dual, SPDT Analog switch, HI3-5043-5	001- U1	390-5043-
19	IC, Quad Op Amp, TL084ACN	001- U2	392-00004
20	IC, Op Amp, 082	001- U3	392-00006
21			
22	Field Effect Transistor, 2N4857	001- T1	702-00006
23			
24	Ziener Diode, 18V, .5 W	002- D1,2	293-0A180
25			
26	Poteniometer, Trim, 10KΩ, horizontal	001- R1	575-C0103
27	Poteniometer, Trim, 20KΩ, vertical	001- R19	575-A0203
28			
29	Capacitor, Variable, 5-25 pF	001- C14	162-A0250
30			
31	Capacitor, 27 pF, 50V, 10%	001- C3	160-AJ270
32	Capacitor, .001 uF, 25V, 10%	001- C6	160-AJ102
33	Capacitor, .1 uF, 50V, 20%	002- C4,5	160-AB104
34	Capacitor, 2.2 uF, 25V, 10%	004- C7,8,17,18	163-BW22A
35	Capacitor, 10 uF, 16V, 20%	002- C1,2	163-AC100
36	Capacitor, .001 uF, 50V, 1%	002- C10,11	164-BA102
37	Capacitor, .01 uF, 50V, 1%	001- C9	164-BA103
38	Capacitor, .022 uF, 50V, 5%	002- C15,16	164-BB223
39	Capacitor, .047 uF, 50V, 5%	001- C19	164-BB473
40	Capacitor, 75 pF, 50V, 5%	001- C13	165-BB750
41	Capacitor, 100 pF, 50V, 5%	001- C12	165-BB101
42			
43	Resistor, 51Ω, 1/4 W, 5%, Carbon film	001- R3	571-B51.0
44	Resistor, 100Ω, 1/4 W, 5%, Carbon film	001- R28	571-B10.1
45	Resistor, 270Ω, 1/4 W, 5%, Carbon film	001- R15	571-B27.1
46	Resistor, 1.0K, 1/4 W, 5%, Carbon film	002- R10,11	571-B10.2
47	Resistor, 10K, 1/4 W, 5%, Carbon film	001- R16	571-B10.3
48	Resistor, 51K, 1/4 W, 5%, Carbon film	001- R14	571-B51.3
49	Resistor, 100K, 1/4 W, 5%, Carbon film	001- R4	571-B10.4
50	Resistor, 200K, 1/4 W, 5%, Carbon film	001- R20	571-B20.4
51	Resistor, 5.1M, 1/4 W, 5%, Carbon film	003- R2,12,13	571-B51.5

Input Amplifier Bill of Material

	1	2	3	4	5	6	7	8	9	10	11	12	13
52													
53		Resistor, 1.02K, 1/4 W, 1%, Carbon film						003-				R17,18,27	571-N1021
54		Resistor, 1.82K, 1/4 W, 1%, Carbon film						001-				R21	571-N1821
55		Resistor, 4.53K, 1/4 W, 1%, Carbon film						001-				R9	571-N4531
56		Resistor, 4.99K, 1/4 W, 1%, Carbon Film						001-				R6	571-N4991
57		Resistor, 9.09K, 1/4 W, 1%, Carbon film						001-				R26	571-N9091
58		Resistor, 18.2K, 1/4 W, 1%, Carbon film						001-				R22	571-N1822
59		Resistor, 22.1K, 1/4 W, 1%, Carbon film						001-				R23	571-N2212
60		Resistor, 41.2K, 1/4 W, 1%, Carbon film						003-				R8,24,25	571-N4122
61		Resistor, 45.3K, 1/4 W, 1%, Carbon film						001-				R7	571-N4532

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	DEFINED TERMINAL 3 AND 4	1-20-88	LUS


INPUT AMPLIFIER
(SEE IA-110 MANUAL)
SIGNAL INPUT
COMPRESSOR OUTPUT
EXT COMM
115/230 VAC
50/60 HZ
40 VA
POWER
ON
OFF
- 2 BYPASS 3 +12 V 4 MC 5 START 6 J 7 NO 8 INTLK 9 F CL 10 GND 11 F.OP 12 13 MC 14 C 15 NC 16 D.O 17 DLY 18 MC 19 S.O 20 C 21 NO 22 STRT 23 RST 24 +5V

3 FROM SERVO

TO POWER AMPLIFIER

EXTERNAL SERIAL COMMUNICATION

NOT USED 1

+12 Vdc

REF

REMOTE RESET (MOMENTARY) — SAME AS FRONT PANEL

REMOTE START (MOMENTARY)

CLOSED IS BYPASS

+5 Vdc (TERM. 24)

START RELAY CONTACTS CHANGE STATE WHEN THE OUTPUT IS NOT COMPRESSED. (OPERATE OR BYPASS)
- NORMALLY CLOSED
- COMMON
- NORMALLY OPEN

- NORMALLY OPEN
- COMMON
- NORMALLY CLOSED

LOWER LIMIT RELAY CONTACTS CHANGE STATE WHEN THE LOWER LIMIT IS EXCEEDED AFTER START IS PRESSED

- NORMALLY OPEN
- COMMON
- NORMALLY CLOSED

DELAYED SHUT DOWN RELAY CONTACTS CHANGE STATE APPROXIMATELY 1/2 SECOND AFTER SHUT DOWN

FAULT WHEN CLOSED INTERLOCK LOOP

FAULT WHEN OPEN INTERLOCK LOOP (SEE NOTE 1)

- NORMALLY OPEN
- COMMON
- NORMALLY CLOSED

SHUT DOWN RELAY CONTACTS CHANGE STATE UPON SHUT DOWN (SEE NOTE 2)

NOTE:

1.) WHEN FAULT OPEN INTERLOCKS ARE USED THE SHUNT, XB, MUST BE REMOVED. THE SHUNT MUST BE IN PLACE IF EXTERNAL CONTACT IS NOT MADE BETWEEN TERMINALS B & 12.

2.) SHUT DOWN OR DELAYED SHUT DOWN RELAY CONTACTS SHOULD BE USED TO SHUT DOWN SYSTEM GAIN UPON SHUT DOWN IN ORDER TO PREVENT INSTANTANEOUS OPEN LOOP OPERATION WHEN THE OUTPUT IS DECOMPRESSED.

3. SIGNAL COMPRESSOR & EXTERNAL COMMUNICATIONS CONNECTIONS ARE COMPLETELY ISOLATED & MUST HAVE THE CONNECTOR SHELL (BODY) RETURNED TO THE APPROPRIATE GROUND TO FUNCTION PROPERLY.

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO.

APPROVALS	DATE
DRAWN LUS	4-20-87
CHECKED	

INTERCONNECT GUIDE

TM-108

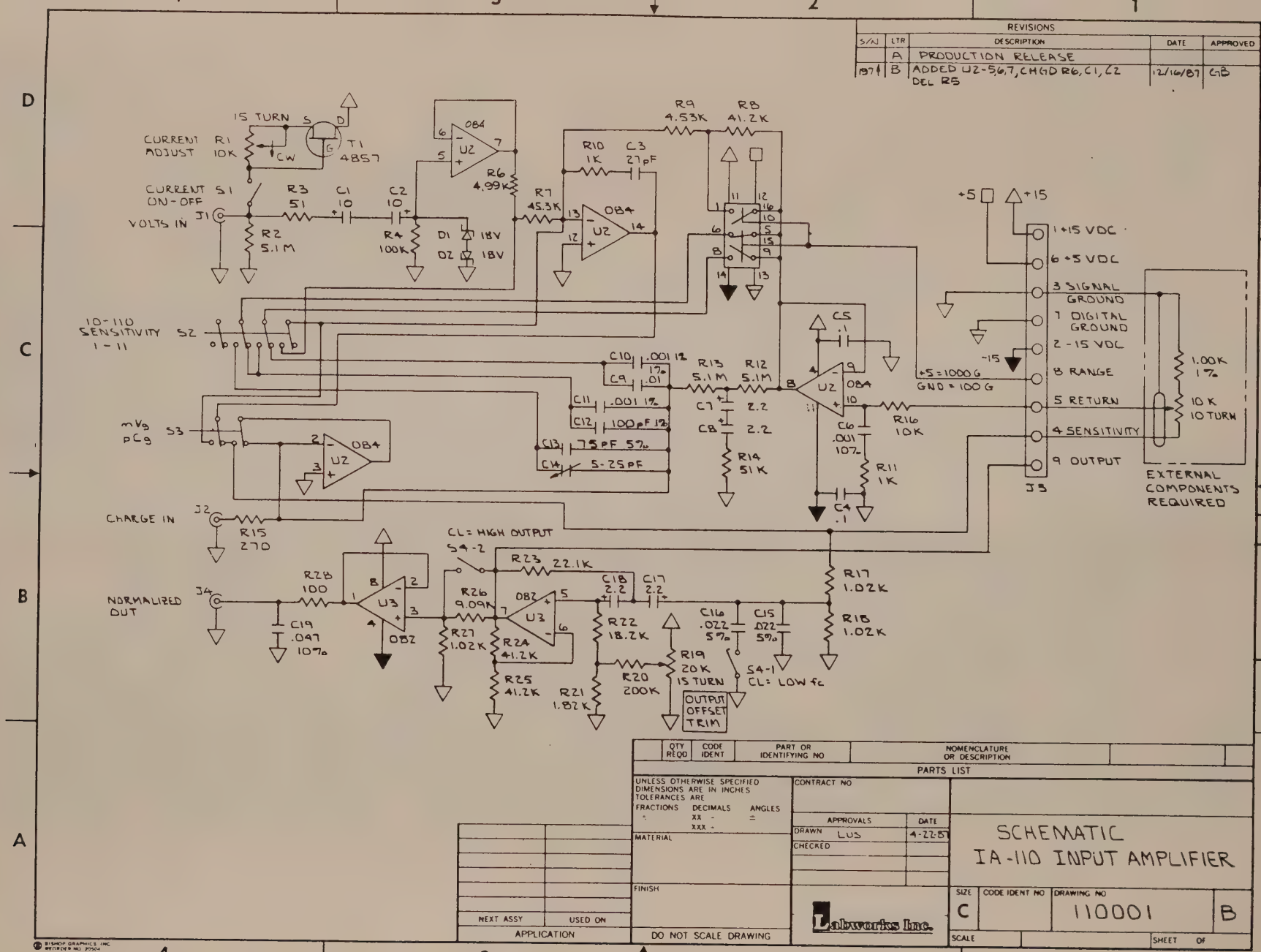
SIZE	CODE IDENT NO	DRAWING NO.	REV
C		108015	A

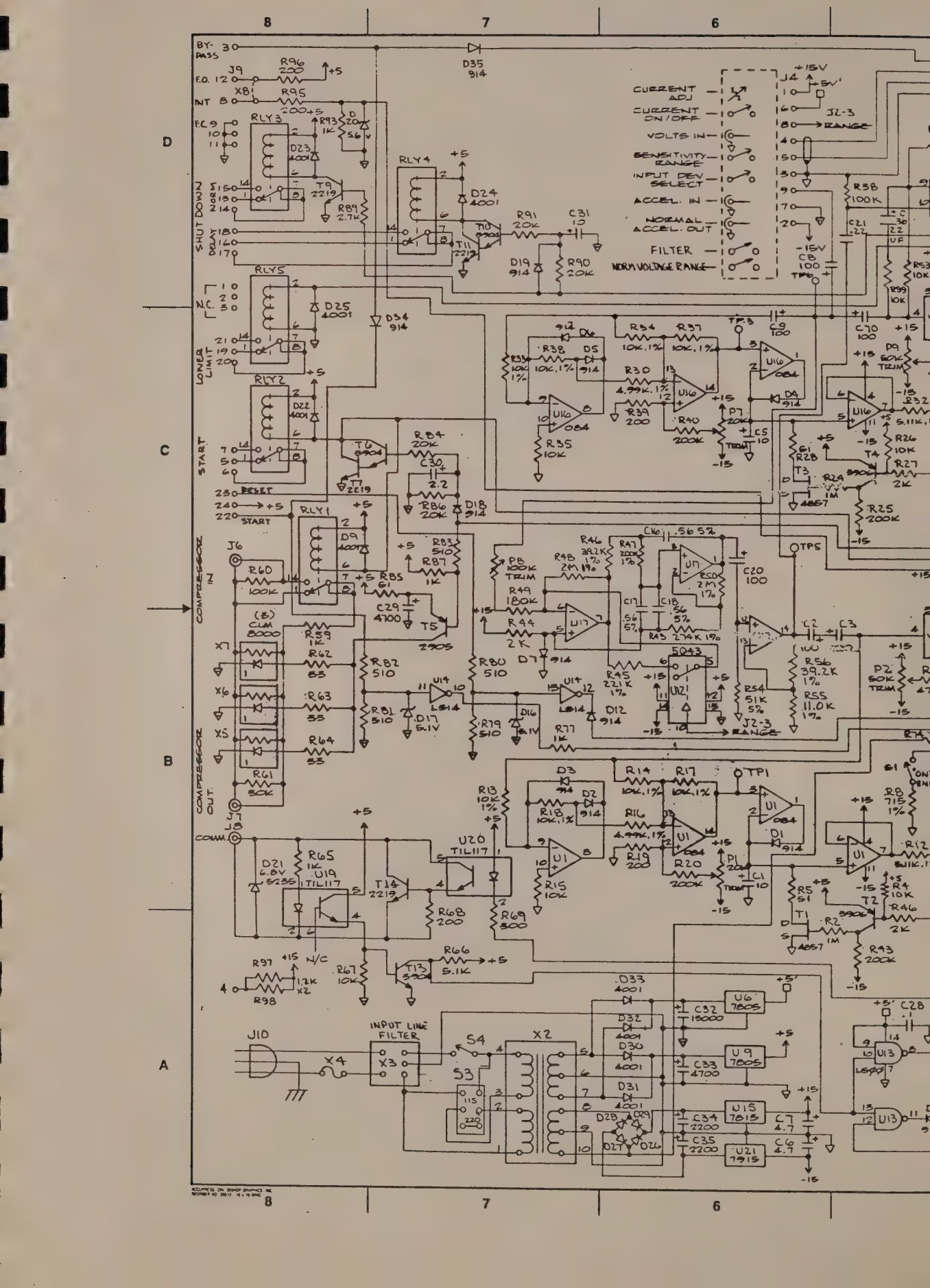
SCALE NONE SHEET 1 OF 1

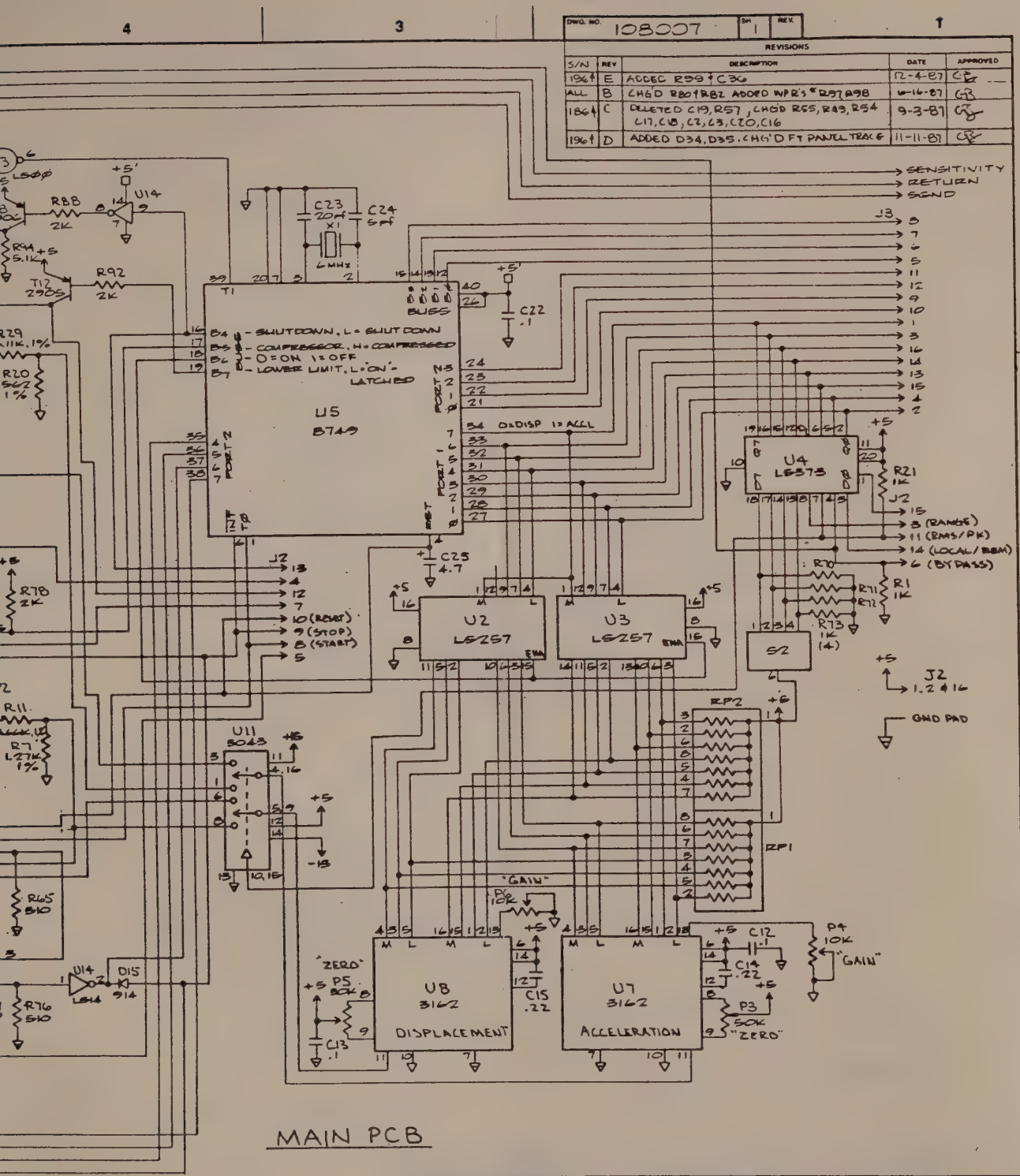
NEXT ASSY	USED ON
	TAP-10000

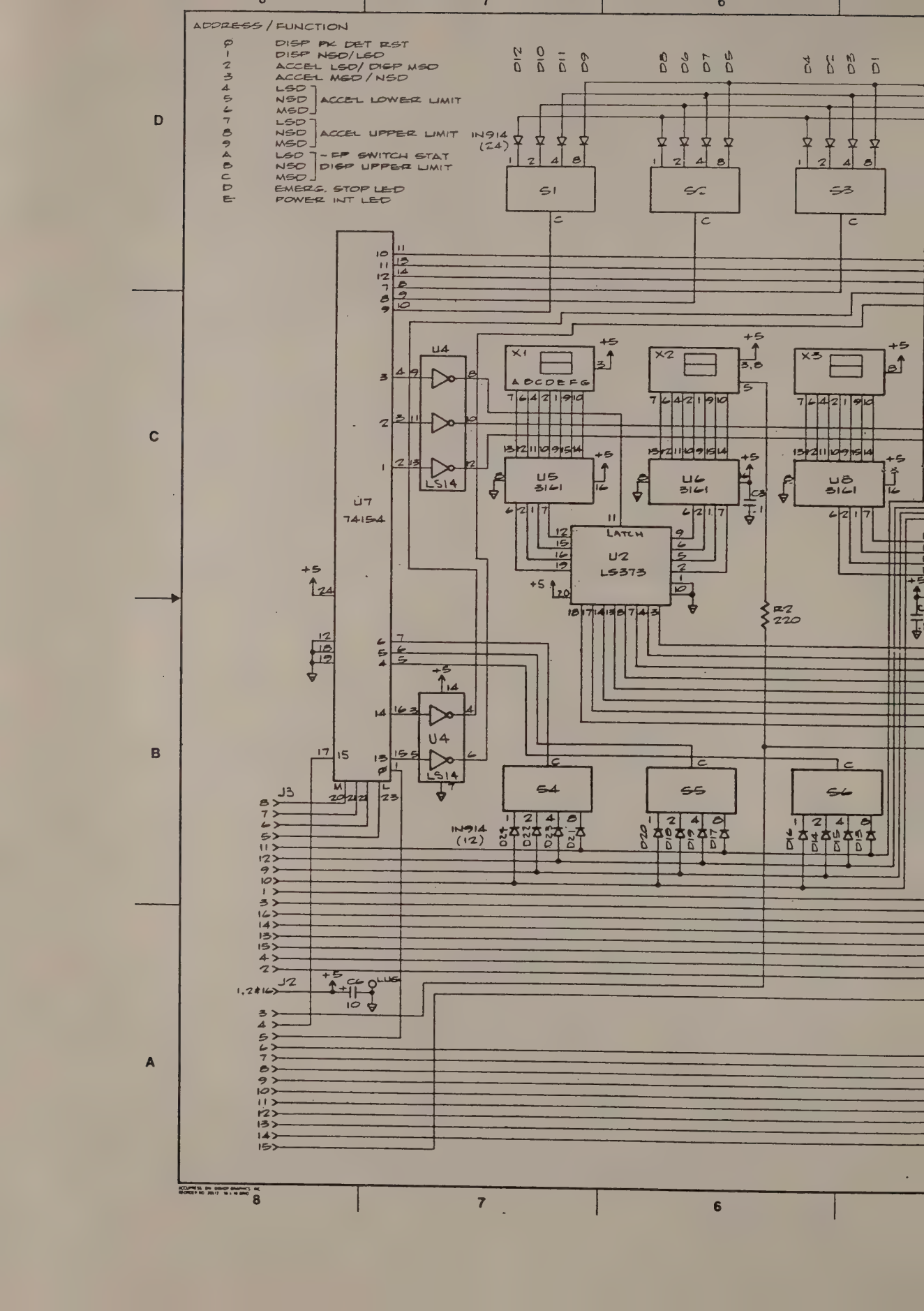
APPLICATION

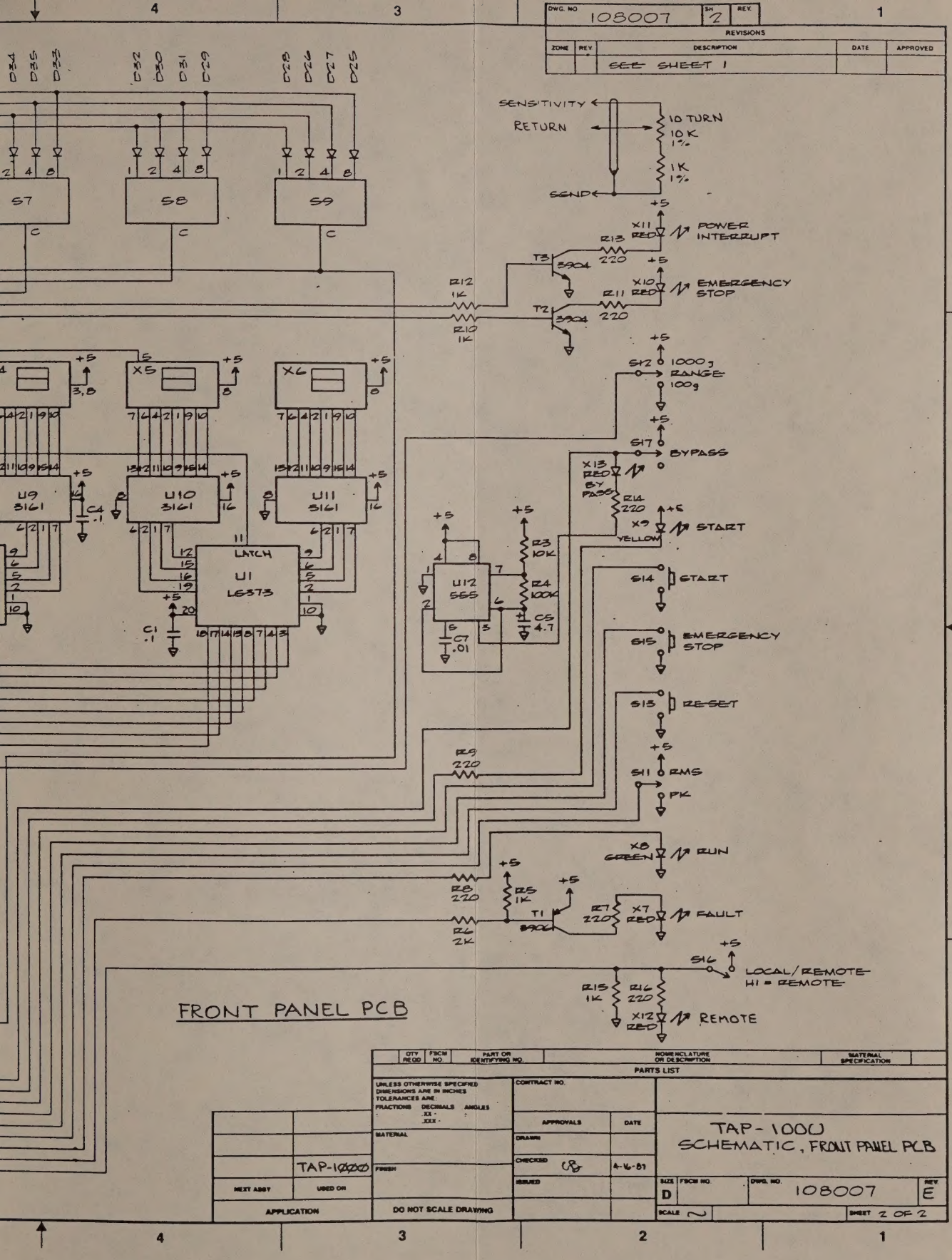
BISHOP GRAPHICS INC REORDER NO 30904


REVISIONS
S/N | LTR | DESCRIPTION | DATE | APPROVED
A | PRODUCTION RELEASE
B | ADDED U2-5,6,7, CHGD R6, C1, C2 DEL R5 | 12/16/87 | GB
15 TURN
CURRENT ADJUST R1 10K CW
T1 4857
CURRENT ON-OFF S1
VOLTS IN J1
R2 5.1M
R3 51
C1 10
C2 10
R4 100K
D1 18V
D2 18V
U2 OB4
R6 4.99K
R7 45.3K
R10 1K
C3 27pF
R9 4.53K
R8 41.2K
+5
+15
1 +15 VDC
6 +5 VDC
3 SIGNAL GROUND
7 DIGITAL GROUND
2 -15 VDC
8 RANGE
5 RETURN
4 SENSITIVITY
9 OUTPUT
J3
1.00K 1%
10 K 10 TURN
EXTERNAL COMPONENTS REQUIRED
10-110 SENSITIVITY S2
1-11
C10 .001 1%
C9 .01
C11 .001 1%
C12 100pF 1%
C13 75pF 5%
C14 5-25pF
R13 5.1M
R12 5.1M
C7 2.2
C8 2.2
R19 51K
C5 .1
C6 .001 10%
R16 10K
R11 1K
C4 .1
+5=1000 G
GND=100 G
-15
mVg pCg S3
U3 OB2
CHARGE IN J2
R15 270
CL=HIGH OUTPUT
S4-2
R23 22.1K
R17 1.02K
R18 1.02K
C18 2.2
C17 2.2
C16 .022 5%
C15 .022 5%
S4-1
CL=LOW fc
R22 18.2K
R20 200K
R19 20K 15 TURN
OUTPUT OFFSET TRIM
R21 1.82K
R24 41.2K
R25 41.2K
R26 9.09K
R27 1.02K
R28 100
C19 .097 10%
NORMALIZED OUT J4
QTY REQD | CODE IDENT | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION
PARTS LIST
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE
FRACTIONS DECIMALS ANGLES
XX ±
XXX ±
CONTRACT NO
APPROVALS | DATE
DRAWN LUS 4-22-87
CHECKED
MATERIAL
FINISH
NEXT ASSY | USED ON
APPLICATION
DO NOT SCALE DRAWING
Labworks Inc.
SCHEMATIC
IA-110 INPUT AMPLIFIER
SIZE C | CODE IDENT NO | DRAWING NO 110001 | B
SCALE | SHEET OF


8
7
6
D
C
B
A
BY-PASS
F.O.
INT
F.C.
SHUT DOWN DELAY
N.C.
LOWER LIMIT
START
COMPRESSOR IN
COMPRESSOR OUT
COMM
RESET
START
CURRENT ADJ
CURRENT ON/OFF
VOLTS IN
SENSITIVITY RANGE
INPUT DEV SELECT
ACCEL. IN
NORMAL ACCEL. OUT
FILTER
NORM VOLTAGE RANGE
J2-3 RANGE
INPUT LINE FILTER
+15V
-15V
+5V
TP1
TP3
TP5
TP6


DWG. NO. 108007
REVISIONS
S/N REV DESCRIPTION DATE APPROVED
1964 E ADDED R99 & C36 12-4-87
ALL B CHG'D RB0 TO RB2 ADDED WPR'S & R97,R98 6-16-87
1864 C DELETED C19,R57, CHG'D R55,R43,R54 C17,C18,C2,C3,C10,C16 9-3-87
1964 D ADDED D34,D35. CHG'D FT PANEL TRACE 11-11-87
SENSITIVITY
RETURN
SGND
J3
U5
8749
BUSS
B4 - SHUTDOWN, L = SHUT DOWN
B5 - COMPRESSOR, H = COMPRESSED
B6 - O=ON 1=OFF
B7 - LOWER LIMIT, L='ON' - LATCHED
PORT 3
PORT 2
PORT 1
PORT 0
D=DISP 1=ACCL
U4
LS373
R21
1K
J2
15
3 (RANGE)
11 (RMS/PK)
14 (LOCAL/REM)
6 (BYPASS)
R70
R71
R72
R73
1K (4)
R1
1K
S2
J2
1,2,4,16
GND PAD
U2
LS257
U3
LS257
ENA
RP2
RP1
U11
5043
+15
-15
"GAIN"
P6
10K
"ZERO"
P5
50K
U8
3162
DISPLACEMENT
U7
3162
ACCELERATION
C15
.22
C13
.1
C12
.1
C14
.22
P4
10K
"GAIN"
P3
50K
"ZERO"
U14
LS14
D15
914
R88
2K
R92
2K
R94
5.1K
T12
2905
R20
562
1%
R78
2K
R11
R7
1.27K
1%
R65
510
R76
510
C23
20pf
C24
5pf
X1
4MHz
C22
.1
C25
4.7
J2
13
4
12
7
10 (RESET)
9 (STOP)
8 (START)
5
MAIN PCB
PARTS LIST
QTY REQD
FSCM NO
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL SPECIFICATION
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
.XX ±
.XXX ±
CONTRACT NO.
APPROVALS DATE
DRAWN
CHECKED CRB 4-6-87
ISSUED
MATERIAL
FINISH
DO NOT SCALE DRAWING
TAP-10000
NEXT ASSY USED ON
APPLICATION
TAP-1000
SCHEMATIC, MAIN PCB
SIZE D
FSCM NO.
DWG. NO. 108007
REV E
SCALE ~
SHEET 1 OF 2


ADDRESS / FUNCTION
0 DISP PK DET RST
1 DISP NSD/LSD
2 ACCEL LSD/ DISP MSD
3 ACCEL MSD / NSD
4 LSD
5 NSD ACCEL LOWER LIMIT
6 MSD
7 LSD
8 NSD ACCEL UPPER LIMIT
9 MSD
A LSD - EP SWITCH STAT
B NSD DISP UPPER LIMIT
C MSD
D EMERG. STOP LED
E POWER INT LED
D12 D10 D11 D9
D8 D6 D7 D5
D4 D2 D3 D1
IN914 (24)
S1
S2
S3
U4
LS14
X1
X2
X3
A B C D E F G
U5 3161
U6 3161
U7 74154
U2 LS373
LATCH
+5
R2 220
C1 .1
C4 10
J3
J2
IN914 (12)
S4
S5
S6


DWG. NO 108007
SH 2
REV
REVISIONS
ZONE | REV | DESCRIPTION | DATE | APPROVED
SEE SHEET 1
SENSITIVITY
RETURN
10 TURN 10K 1%
1K 1%
SEND
+5
X11 RED
POWER INTERRUPT
R13 220
T3 3904
X10 RED
EMERGENCY STOP
R11 220
T2 3904
R12 1K
R10 1K
S12 1000g RANGE 100g
S17 BYPASS
X13 RED BY PASS
R14 220
X9 YELLOW
START
S14 START
S15 EMERGENCY STOP
S13 RESET
S11 RMS
PK
X8 GREEN
RUN
X7 RED
FAULT
T1 3904
R8 220
R5 1K
R6 2K
R7 220
S16 LOCAL/REMOTE
HI = REMOTE
R15 1K
R16 220
X12 RED
REMOTE
U9 3161
U10 3161
U11 3161
U1 LS373
LATCH
U12 555
R3 10K
R4 100K
C5 4.7
C7 .01
C1 .1
C4 .1
R9 220
S7
S8
S9
X5
X6
D34 D35 D33 D32 D30 D31 D29 D28 D26 D27 D25
FRONT PANEL PCB
PARTS LIST
QTY REQD | FSCM NO. | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MATERIAL SPECIFICATION
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX .XXX
CONTRACT NO.
APPROVALS | DATE
DRAWN
CHECKED 4-6-81
ISSUED
MATERIAL
FINISH
TAP-100U
NEXT ASSY | USED ON
APPLICATION
DO NOT SCALE DRAWING
TAP-1000
SCHEMATIC, FRONT PANEL PCB
SIZE D | FSCM NO. | DWG. NO. 108007 | REV E
SCALE ~ | SHEET 2 OF 2

MP MASTER
MA29144